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A Foraminiferal Biostratigraphy of the Upper Cretaceous of the Southern North Sea Basin (UK Sector).

by

Kim C. Ball B.Sc.

Thesis submitted in partial fulfilment for the Degree of Doctor of Philosophy to the Council for National Academic Awards.

Research conducted at Plymouth Polytechnic
sponsored by NERC and
Shell (UK) Exploration & Production Ltd.

September 1985.

DECLARATION

This is to certify that the work submitted in partial fulfilment for the Degree of Doctor of Philosophy under the title "A Foraminiferal Biostratigraphy of the Upper Cretaceous of the Southern North Sea Basin (UK Sector)" is the result of original work.

All authors and works consulted are fully acknowledged. No part of this work has been submitted for any other degree and is not concurrently submitted in candidature for any other degree.

Candidate

KIM C. BALL

Research supervisor

PROF. M.B. HART

During the course of this research a short paper written by the author was published by the British Geological Survey in BGS short communications 6 (Rep. Br. Geol. Surv., Vol. 16, No. 10. 1985 for 1984), entitled "The foraminifer Vaginulinopsis scalariformis - a new record from the Santonian (Cretaceous) of the southern North Sea Basin". A copy of this publication is enclosed within this thesis.

A second paper entitled "Unusually large Late Campanian - Early Maastrichtian foraminifera from the Southern North Sea Basin" has recently been accepted for publication by the Journal of Micropalaeontology (for 1986). A copy of the manuscript is enclosed within this thesis.

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ABSTRACT

KIM C BALL "A Foraminiferal Biostratigraphy of the Upper Cretaceous of the Southern North Sea Basin (UK Sector)".

The Cenomanian to Maastrictian foraminifera have been studied from borehole material (ditchcuttings) of three wells - 44/2-1, 49/19-1 and 49/20-2 - drilled by Shell (UK) Exploration & Production Ltd in the Southern North Sea Basin. The microfaunas have been utilized in the formulation of a zonal scheme comprising twelve foraminiferal biozones based on 'tops' (highest occurrences) of selected taxa; the taxonomy of the stratigraphically diagnostic forms is briefly discussed.

The major lithostratigraphic units of the Dutch and British sectors of the Upper Cretaceous of the Southern North Sea Basin are recognised from Gamma Ray and Formation Density wireline log signitures (where available); these are the Chalk Group and the Texel and Ommelanden Formations.

The biozones are related to the lithostratigraphic units in the three well sections and these are correlated across the Southern North Sea Basin. The dating and correlation of the sequences shows significant differences in thicknesses to exist between the sections; these are tentatively related to position relative to 'palaeo-highs', differential subsidence and/or uplift along inversion axes in the area.

CHAPTER 1

INTRODUCTION

The earliest contributions to the study of foraminifera began in the eighteenth centurary and involved mainly the study of recent material collected from the shores around the British Isles, the continental shelf and oceanic basins. These early micropalaeontologists endeavoured to acurately describe and record all their observations, and to define principles for the discipline where appropriate. During this period, the study of fossil foraminifera from the British Isles was largely neglected, and fell behind the work taking place in Europe at that time. By the turn of the nineteenth century, still very little was known of Upper Cretaceous or Mesozoic foraminifera as a whole.

With the advent of the first World War, an increase in the demand for petroleum resulted in an upsurge of exploration activities throughout Europe and the British Isles. This in turn resulted in a sudden increase in interest in the discipline of micropaleontology, and especially in foraminifera because of the recognition of their potential use as a correlative tool; the switch from the early descriptive studies of foraminiferid taxa to biostratigraphy and correlation was rapid. Since 1965, there has been intensive exploration of the North Sea Basin, which has meant the drilling of several hundred offshore boreholes. These offshore sequences have been studied in detail biostratigraphically by the oil industry to provide a basis for stratigraphic subdivision and correlation.

Cretaceous foraminifera were little used in stratigraphy in the British Isles before 1948, but it was in that year that Williams-Mitchell, from his work on the Portsdown borehole, recognised a series of microfaunal zones for the Upper Cretaceous. This

stratigraphic approach to the study of foraminifera was quickly applied to Northern Ireland by McGugan (1957). There then followed a series of publications (notably Barnard 1958, 1963, and Barnard & Banner 1953) on selected taxa, but a stratigraphic approach was again used by Jefferies (1962) in his paleontological and stratigraphic analysis of the Actinocamax plenus subzone of S.E. England. Jefferies work was important as it demonstrated the value of a detailed study of a small part of the Cretaceous succession, and this approach continues to the present day, with numerous projects during the last twenty years. These include work by Barr (1962, 1966a), Owens (1970) unpublished work on the Turonian, Carter and Harts work on the mid-Cretaceous of S.W. England (1977), Baileys unpublished work on the Lower Senonian of Southern England (1978) and Swiecickis unpublished work on the Campanian and Maastrichtian chalks of the U.K. (1980). These detailed studies have resulted in the proposal of fine zonation schemes for individual parts of the chalk succession. These have provided the foundation for the present study in which an attempt is made to erect a zonal scheme for the Upper Cretaceous of the southern North Sea Basin where there is an opportunity to study long, and relatively uninterrupted sequences through the chalk. No attempt is made at a monographic study of the taxa involved, but the different species are discussed briefly and a zonal scheme comprising 12 zones is proposed covering the Cenomanian to Maastrichtian interval. The proposed zonal scheme is based entirely on the foraminiferal assemblages recorded; no other stratigraphic information was made available or provided from other fossil groups.

During the present study, material was examined from 3 well sections from the Southern North Sea Basin (44/2-1, 49/19-1 and 49/20-2). No material has been examined from other boreholes from the North Sea Basin, but it is hoped that this work might provide an initial basis for

more detailed work on the Upper Cretaceous successions offshore so that a more detailed and refined zonation can be achieved for this economically important system.

CHAPTER 2

GEOLOGICAL HISTORY OF THE NORTH SEA BASIN

Detailed accounts of the geology of the North Sea Basin are to be found in the volumes edited by Woodland (1975), Illing & Hobson (1981) and Glennie (1984), and in papers by P. Ziegler (1975(a); 1975(b); 1977; 1978), W. Ziegler (1975), Selley (1975), and Irving, Nork & Couillard (1974).

The present day North Sea occupies a broadly triangular shaped area, delimited to the east by the Pre-Cambrian craton of the Baltic Shield, to the south by the degraded east-west trending Variscan fold belt, and to the northwest by the northeast - southwest trending roots of the Old Caledonian mountain chain (Fig. 2.1) (Selley 1975).

The North Sea area once lay at the boundary between the Laurentian - Greenland plate and the Baltic - European plate, and during pre-Permian times, it was subjected to intermittent tension and compression as these plates alternately came together and separated. The first major cycle of movements (the Caledonide orogeny) began in late Pre-Cambrian times, when the Iapetus Ocean lay between Greenland and northwest Europe. Marine sands, limestones and shales, sometimes bituminous, were deposited on the continental margins during separation of the plates and deep-sea submarine channel sands, turbidites and graptolitic shales were deposited on the continental slopes. The sediments were folded and metamorphosed during compressional phases (P. Ziegler 1978). These sporadic movements culminated during Late Silurian - Early Devonian times. The closing of the Iapetus Ocean at

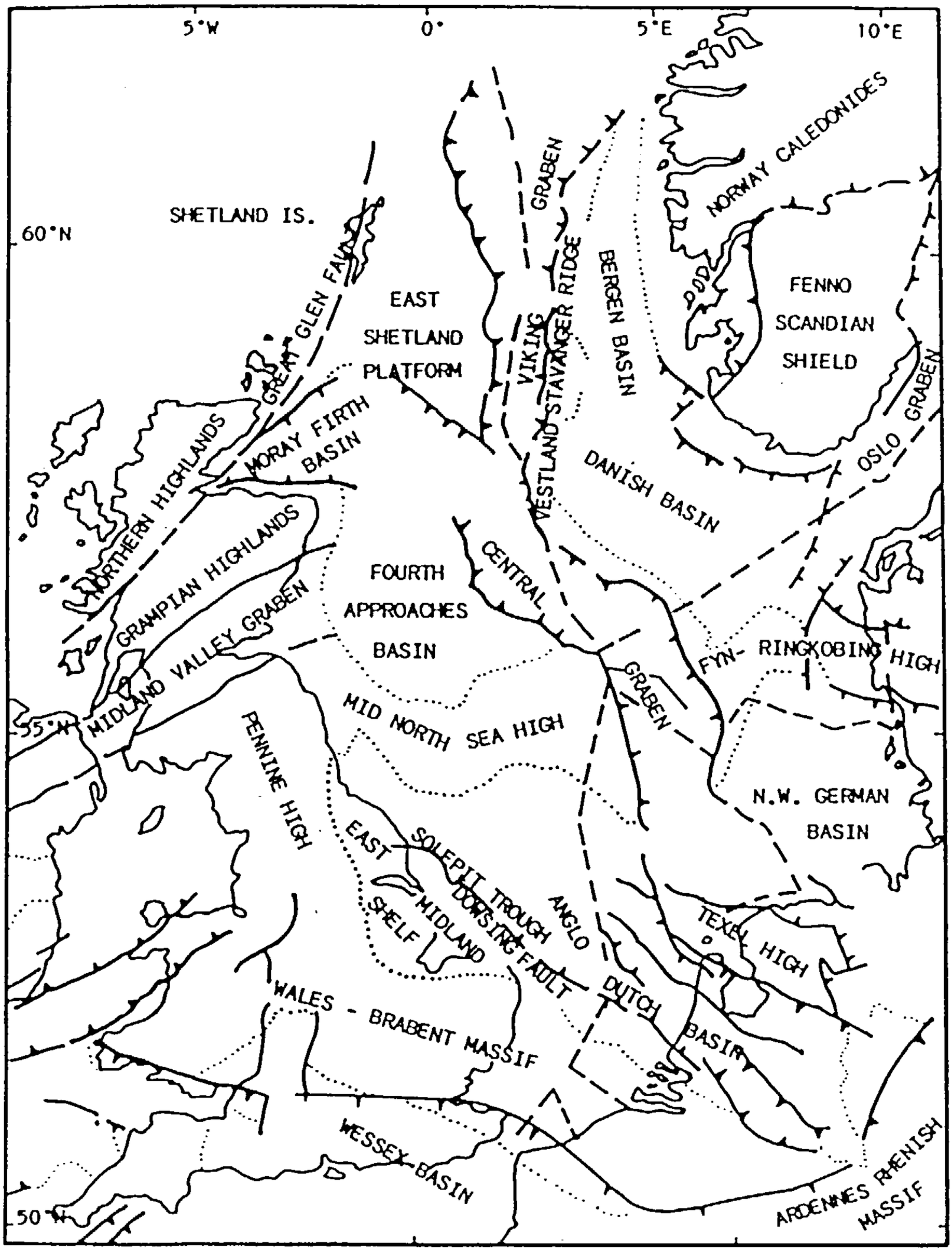

Fig. 2.1 Major Mesozoic and Tertiary structural units in the North Sea (After Kent 1975)

the end of the Silurian resulted in the sediments along the geosynclinal axis being tightly folded, faulted and locally overthrust to form the Caledonide mountain chain. As the Greenland and European plates sheared passed each other, wrench faults were established which persist to the present day (e.g. the Great Glen Fault, stretching from the Shetland Isles to Northern Ireland and the Tornquist-Teisseyre line, stretching from southern Norway to Poland). Tectonic forces were weaker to either side of the fold belt and in these areas, the sediments were gently folded.

During Devonian times, thick beds of continental sediments (Old Red Sandstone) were deposited in the fault-bounded basins within and adjacent to the Caledonian mountain chain. These are locally present in the Welsh Borderlands, the Midland Valley of Scotland and in the Orkneys. Continental strata have been encountered in the northern North Sea basin and bituminous shales with veins of hydrocarbons occur in the lacustrine Orcadian Basin in northeast Scotland and the Orkney Islands. To the south of this continental realm an east-west marine trough - the Proto-Tethys - had existed since the beginning of the early Paleozoic and would remain so until its closure in the Late Carboniferous resulted in the Variscan orogeny. During the Early Carboniferous, a transgression occurred over the Variscan foreland, in which shelf carbonates, limestones (often reefal) and shales were deposited. These are overlain by paralic, deltaic, sediments, including the Yoredale facies and the Coal Measures of northern England. The Variscan orogeny culminated at the end of the Carboniferous with the formation of a mountain chain. The fold belt emerged from the old trough and consisted of folded basinal deposits intruded by granites such as those of Devon and Cornwall. The Variscan

orogeny brought the compessive history of northwest Europe to a close, apart from the Late Cretaceous-Early Tertiary closure of the Tethys Ocean that had separated Africa and Eurasion, and the creation of the alpine fold chain.

At the beginning of the Permian, the European and Greenland - Laurentian plates began to separate to form the Atlantic Ocean and at this time, the North Sea area experienced a period of prolonged crustal extension. To the north of the present North Sea, a major triple rift junction developed with rifts radiating north-northwest, (parallel to the present coast of East Greenland), southwest (out into the present Atlantic), and south-southeast (down the present North Sea). The latter rift includes the Viking and Central Grabens (Fig. 2.2). During Permo-Triassic times, the rift floors continued to subside and this resulted in a marine transgression across northwestern Europe and eastern Greenland during the Late Triassic and Early Jurassic.

Marine sedimentation continued throughout the Jurassic with inter-bedded shales and sands being deposited. The rifts continued to subside, and jostling of the fault blocks caused sediment thinning and facies changes with erosion of the crests of the structures. The two northern arms of the rift system became active zones of sea-floor spreading as the Norwegian Sea and the north Atlantic opened; the Viking and Central Grabens were "failed rifts", (they rifted but remained continental crust-not oceanic). These movements culminated in phases of block tilting and erosion in the Late Jurassic - Early Cretaceous, usually identified as "the Late Cimmerian Unconformity" (Rawson & Riley 1982).

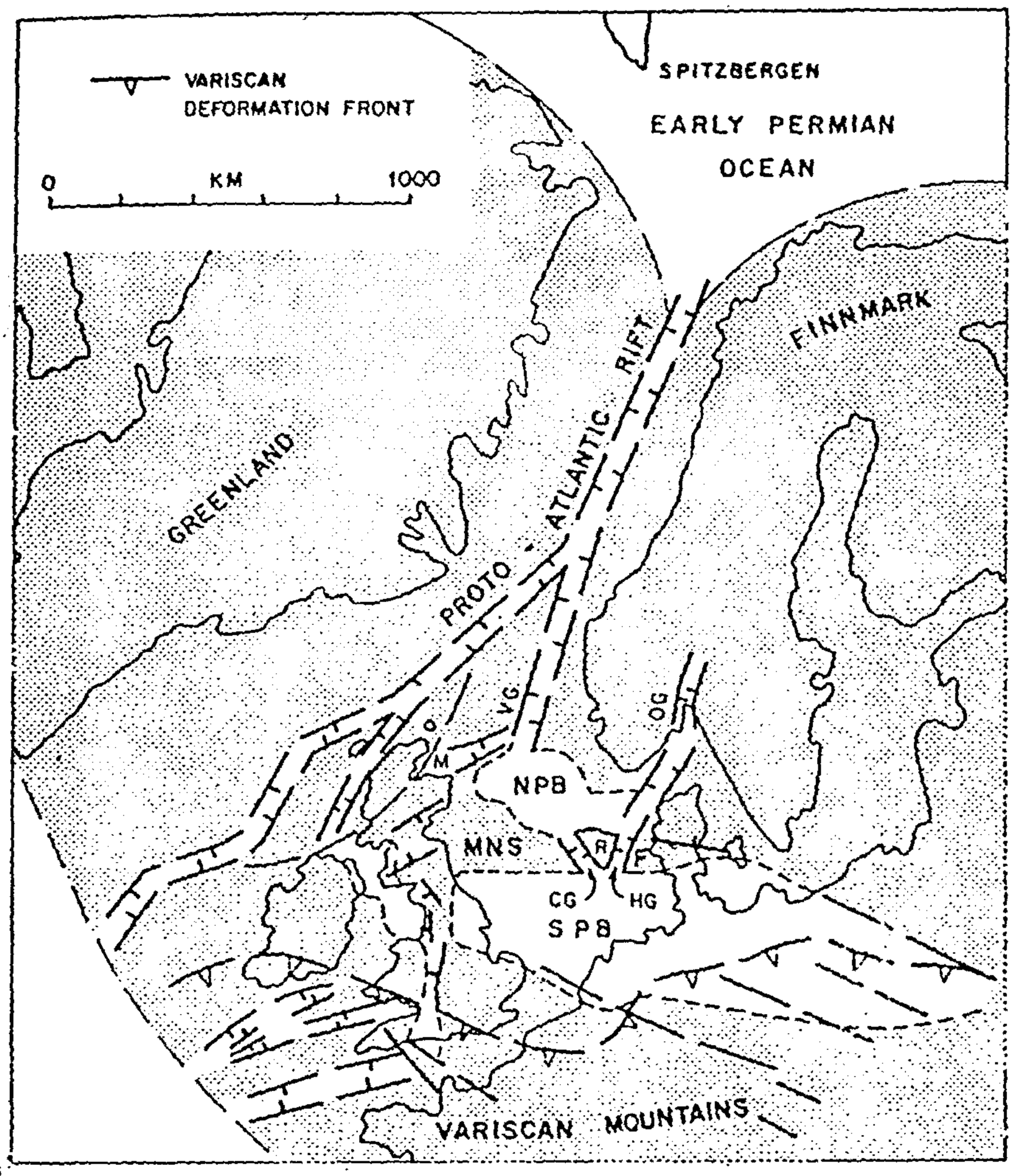

Fig. 2.2 Post-Variscan fault patterns. (from Glennie 1984)

CG Central Graben
HG Horn Graben
M Moray Firth
MNS Mid North Sea High
NPB Northern Permian Basin
OG Oslo Graben
RP Ringkobing-Fyn High
SPB Southern Permian Basin
VG Viking Graben

The Early Cretaceous was essentially a period of transgression and began with the deposition of sands and clays. The margins of the shallow sea were in eastern, northeastern and southern England and in the Western Approaches, where non-marine sandstones and shales of a fluvio-deltaic lake complex were deposited. The Late Cretaceous was a period of tectonic quiescence during which the Chalk was deposited as a continuous sheet throughout the Southern North Sea Basin and over much of the northern sector (Fig. 2.3), although in places it was affected by faulting or halokinesis. The rift continued to subside as shown by thickening in the Central Graben and the presence of resedimented chalk turbidites. In the Viking Graben, the Chalk grades into shales. The Upper Cretaceous stages in the North Sea Basin are considerably thicker than in onshore Britain. This is partly due to the widespread occurrence of Maastrichtian strata which appear to have been transgressive over wide areas. By the end of the Cretaceous, a deeper water facies existed in the centre of a generally simple basin.

The Cretaceous ended with a phase of structural movement (the Laramide disturbances), which reached a climax in Late Maastrichtian times and rapidly faded after the Palaeocene. These movements resulted in the deposition of chalk boulders and unconsolidated sand derived from the basin margins. Uplifting shown by a series of axes of inversion (the Netherlands and Sole Pit Inversions) where Tertiary sediments overstep the Chalk, Jurassic and older rocks, occurred at the rift margins. These axes extend towards the southwest (to the Weald and Mid-Channel Inversions). The shearing and wrenching of the Laramide movements caused complex anticlinal features to develop in the

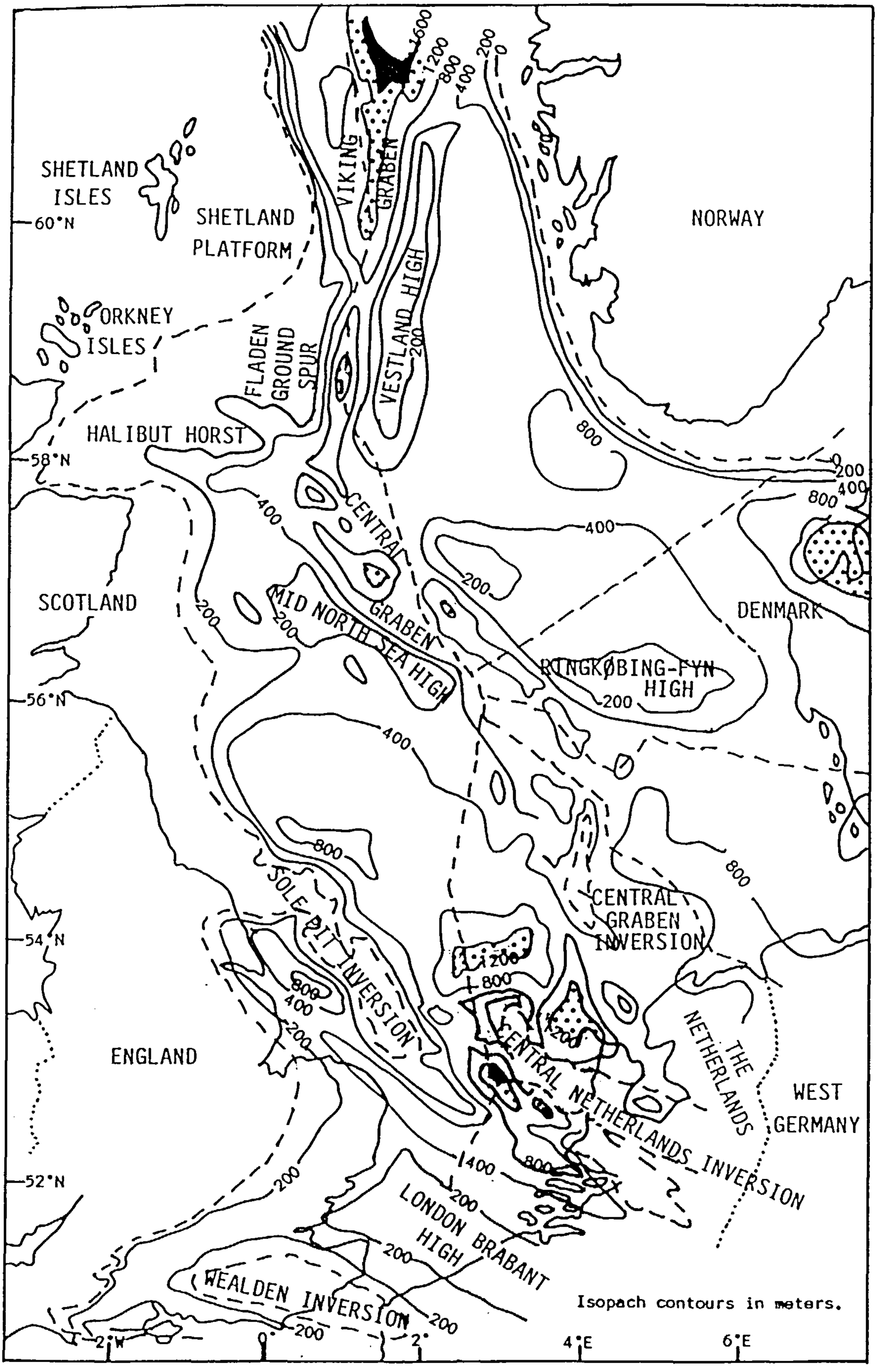

Fig. 2.3 Isopachs of the Chalk Group (Upper Cretaceous and Lower Paleocene) and Shetland Group in the North Sea Basin (After Hancock 1984)

Anglo-Dutch Basin. The major gas fields of the southern UK sector of the North Sea Basin are located on these structural features (Fig. 2.4).

During the Tertiary, subsidence continued in the Viking and Central Grabens but these no longer formed a rift. An essentially simple basin existed which continued to subside until the present day.

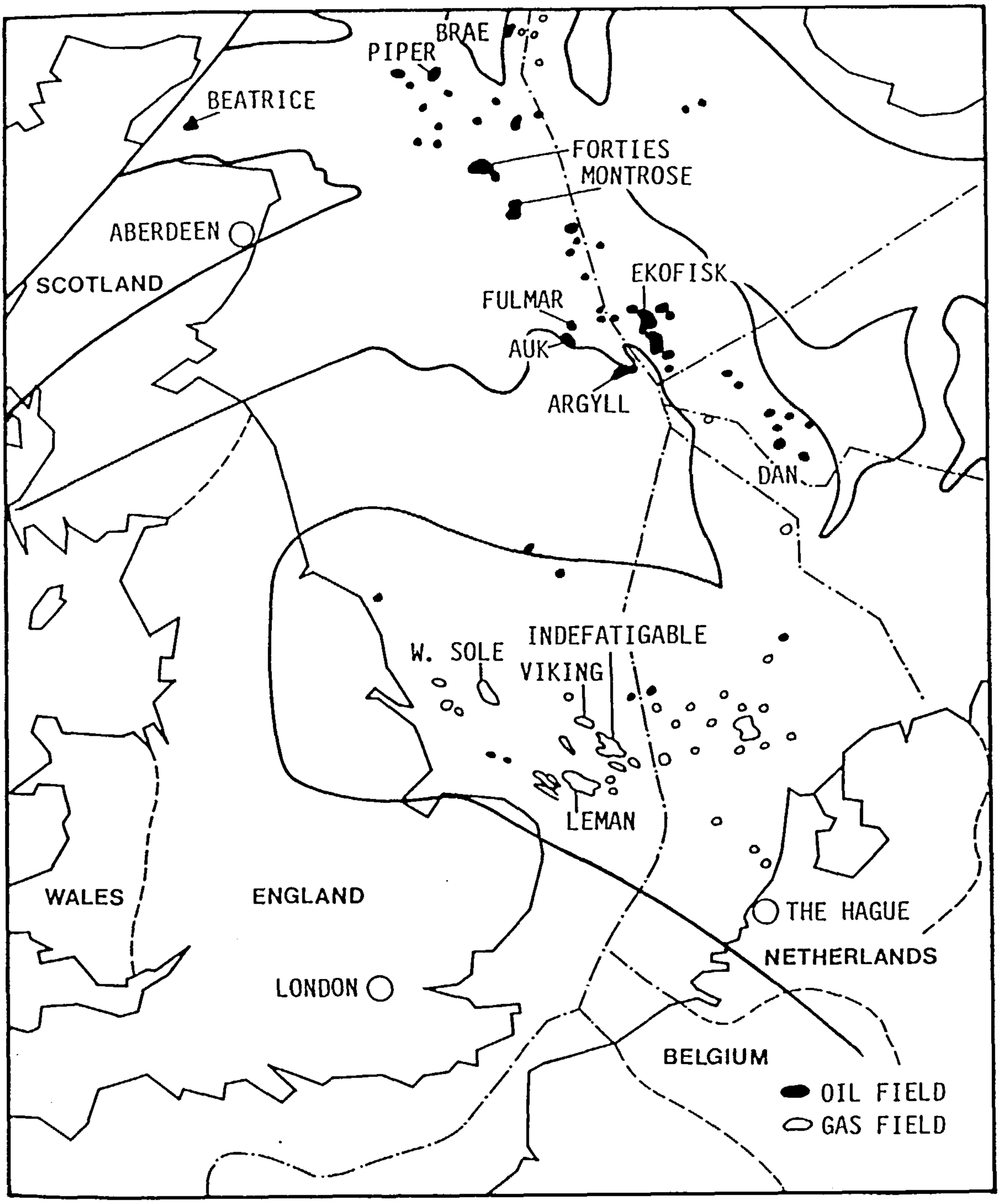

Fig. 2.4 Major named oil and gas fields of the North Sea Basin

CHAPTER 3

CHRONOSTRATIGRAPHIC FRAMEWORK

3.1 Introduction

The Cretaceous System was designated by d'Omalius d'Halloy in 1822 and takes its name from 'Creta', the latin for chalk-the most conspicuous rock type of this age in Europe.

The Cretaceous of the British Isles was first subdivided in the early nineteenth century by William Smith who recognised a three-fold division based on lithology:-

Chalk	(Upper Cretaceous)
Greensand	(Middle Cretaceous)
Gault/Wealden	(Lower Cretaceous)

As no international limit could be agreed for the Middle Cretaceous, a two-fold division is now generally used (Rawson et al. 1978). The Upper Cretaceous corresponds approximately to the Chalk Formation of earlier authors although non-chalk marginal facies are present in south-west England, Northern Ireland and western Scotland.

The main Upper Cretaceous outcrop in the British Isles is confined to a narrow band in eastern England and a larger tract of country in southern England. (Fig. 3.1). Extensive deposits are also known from offshore - in the North Sea (Rhys 1974; Hancock & Scholle 1975), the English Channel (Curry & Smith 1975) and from the South-Western Approaches (Lott et al. 1980; Evans et al. 1981).

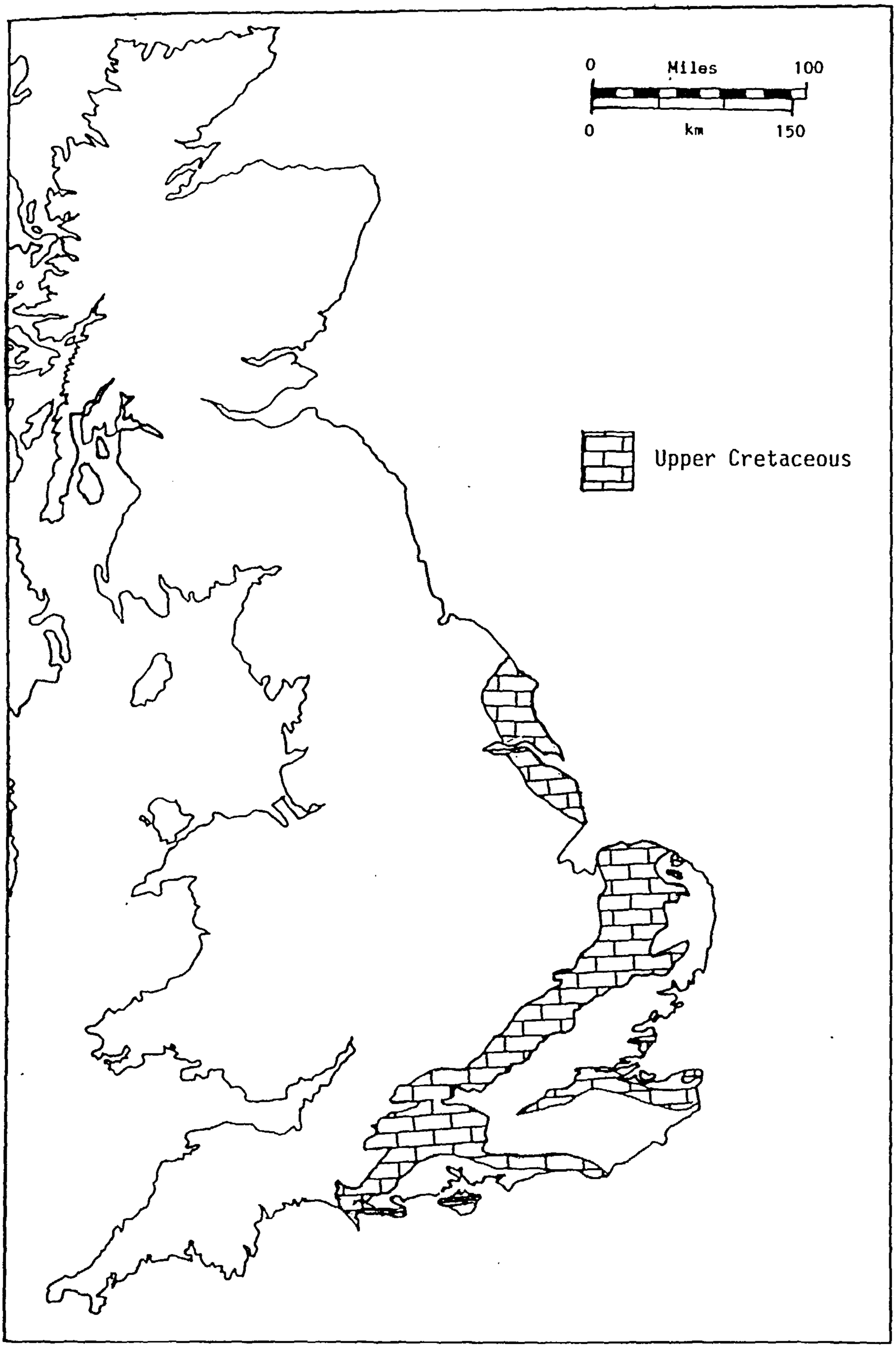

Fig. 3.1 Outcrops of Upper Cretaceous deposits in the British Isles.

The chalk itself has generally been divided into Lower, Middle and Upper on the basis of lithology. The base of the Middle Chalk is marked by the Melbourne Rock (a nodular Chalk with incipient hardgrounds), and the base of the Upper Chalk is marked by the Chalk Rock (a composite hardground). Palaeontological criteria were first used by Barrois (1876) to subdivide the Chalk, and finer and finer subdivisions were gradually established without regard for the relationship between faunas and lithology. Therefore many problems were encountered when standard stage names established in France were applied to the British Cretaceous (discussed below).

3.2 Upper Cretaceous stages

The Upper Cretaceous consists of six stages none of which have stratotypes in the British Isles. The interpretation of some of these stages in Britain is therefore problematic, because their stratotypes occur in areas belonging to a different faunal realm.

Early in the nineteenth century, British geologists began dividing the Cretaceous into local lithological units with little regard to the fauna. Their early nomenclature is summarized by Jukes-Browne & Hill (1900; 1903 pp 1-10). Following his detailed stratigraphical study of the Upper Cretaceous of England and Ireland, Barrois (1876) showed that these previously defined lithological units had distinctive fossil assemblages. Attempts were made to group the zones based on these fossil assemblages so that they might be correlated with the stages set up in France by d'Orbigny (1847, 1850, 1852). As little attention had been paid to the faunas, the zonal schemes tended to be local, ill-defined and facies influenced and the stage boundaries coincided with lithology.

Detailed statigraphic investigations of Late Cretaceous sections throughout Europe are currently being carried out in order to establish criteria for the recognition of stage boundaries that can be correlated with the stratotypes in France and Holland. Many of the results and problems were discussed at the 1983 symposium on Cretaceous Stage Boundaries in Copenhagn and have subsequently been presented in the symposium volume (Bulletin of the Geological Society of Denmark, vol. 33, (1-2), 1984). From these discussions, a set of proposals and recommendations were formulated in an effort to provide guidelines for the final choice for the definition of the Cretaceous stage boundaries, but these as yet remain as proposals and recommendations. Therefore, the chronostratigraphy that is discussed below is that which has been conventionally followed to date.

3.2.1 Cenomanian

The lowest Upper Cretaceous stage (the Cenomanian) was proposed by d'Orbigny (1847, 1850, 1852) following his work on the marginal sands, gravels, marls and chalks of the area around Le Mans, (Roman name Cenomanum), in the Sarthe region of France. No type section was designated but Sarthe remains the type area for the stage. Many of the sections referred to by d'Orbigny have been destroyed, are now overgrown, or have the modern city of Le Mans built on them. In an attempt to clarify the limits of the stage, Marks (1967) proposed a composite section in the area of St. Ulphace-Theligny - Moulin de l'Aunay as a stratotype. Several new exposures are also available in the type area (Carter & Hart 1977).

Within the type area, the base of the stage is defined at the base of the "Argile Glauconieuse à minerai de Fer", (Guiller 1886; Delaunay 1934; Sornay 1957; Hancock 1959; Juignet 1968; Rawson et al. 1978), which overlies unconformably clays of Oxfordian (Jurassic) age. However, there has been no exposure of this horizon in Le Mans for several years (Rawson et al. 1978) and east and north of the city, vertical and lateral facies variations makes correlation and study of the Cenomanian succession very difficult.

According to the macrofauna, the base of the Cenomanian is defined approximately by the appearance of Mantelliceras mantelli (Hancock 1959; Rawson et al. 1978; Harland et al. 1982). In the British Isles, the stage consists of four ammonite zones:-

Upper	Sciponoceras gracile
	Calycoceras naviculare/Eucalyoceras pentagonum
Middle	Acanthoceras rhotomagense
Lower	Mantelliceras mantelli

According to the microfauna, the base of the Cenomanian is defined by the appearance of the fauna of the Rotalipora appenninica (Renz 1936)/Praeglobotruncana delrioensis (Plummer 1931) Zone (Carter & Hart 1977) which includes large numbers of Arenobulimina advena (Cushman

1936) and Flourensina intermedia Ten Dam 1950. This level coincides with the base of the Glauconitic Marl in East Wear Bay, Folkestone (Carter & Hart 1977).

When the Cenomanian stage was first used in Britain, Barrois (1876) equated it with half of the Upper Greensand and part of the Chalk, but later Jukes-Browne and Hill (1896) considered it to be represented by the Lower Chalk. Since then, the lithostratigraphic units of English geologists have frequently been shown in relation to the chronostratigraphic units of French geologists and both have often been misused. Attempts at classification have been few since 1900 and there is still much confusion.

3.2.2. Turonian

The Turonian stage was proposed by d'Orbigny (1842) and takes it's name from Tours (Roman name Turones) or Touraine (Roman name Turonia) in northern France. Subsequently (d'Orbigny 1847), he divided his original stage into two on the basis of its fauna and assigned the lower part to a separate and new stage - the Cenomanian (see 3.2.1. above).

Originally, no stratotype section was proposed for the Turonian but later, d'Orbigny (1852) designated the area between Saumur on the river Loire and Montrichard on the river Cher as type for the stage. Many geologists have not followed strictly the definition of the stage in this limited type area and this has resulted in much confusion. Lecointre (1959) in a paper specifically on the type Turonian emphasized the Cher Valley (both east and west of Montrichard) which led Butt (1966) and Bellier (1971) to refer to the Cher Valley as the

type area and thereby including sections outside d'Orbigny's definition. Prior to this, Sornay (1957) defined the base of the stage as the base of the Inoceramus labiatus (or Mammites nodosoides) Zone. Lecointre (1959) recognised that this faunal association was 'characteristic' of the "craie marneuse and chaux hydraulique" but he also recognised it in the "Sables de Boussse", which does not occur in Touraine and the "Craie à Terebratella carantonensis". Lecointre seems to have regarded these distinctive facies of the basal Turonian as local variations immediately adjacent to the type area. The "Craie à Terebratella carantonensis" is a name used locally in Sarthe for the basement bed of the chalk which is sometimes rich in brachiopods; however, no brachipod - rich basement bed has been recorded at this level from Touraine (Rawson et al. 1978; Robaszynski et al. 1982).

The lowest formation of the type Turonian as defined by d'Orbigny is the "Craie Marneuse". Few ammonites have been recorded from this formation but they include Lewesiceras peramplum and Mammites nodosoides; the first appearance of the latter has been taken to mark the base of the stage. The M. nodosoides Zone is recognisable over much of the world (Rawson et al. 1978; Harland et al. 1982). Much more common in this formation is the bivalve Inoceramus labiatus and this in association with the ammonites M. nodosoides and L. peramplum shows that the formation also falls within the widely used (British) I. labiatus Zone, the base of which is known to coincide elsewhere with the base of the M. nodosoides Zone (Kennedy & Juignet 1973).

No satisfactory macrofaunal subdivision of the British Turonian has been achieved at present; ammonites are scarce and detailed inoceramid biostratigraphy has only been applied to a few British sections.

Therefore, the classic zones used by Rowe (1900-1908) and Jukes-Brown & Hill (1903, 1904) are still used with only slight modification. For the Turonian of the British Isles these are :

Holaster planus Zone
Terebratulina lata Zone
Inoceramus labiatus Zone

The limits of these zones are generally ill-defined and compared to the ammonite zones applied to older parts of the Cretaceous, they are relatively broad divisions.

The European ammonite zones for the Turonian are the :-

Subprionocyclus neptuni Zone
Collingnoniceras woolgari Zone
Mammites nodosoides Zone

The definition of the base of the Turonian in Britain is problematic. If the European standard is to be followed the boundary should be based on *M. nodosoides* which appears within the Melbourne Rock, 2 - 3 metres above the Plenus Marls in Kent and Sussex and is known from Devon to Norfolk. The first appearance of *Inoceramus labiatus* also occurs above the Plenus Marls (Carter & Hart 1977) and this correlates with Lecointre's (1959) observation that *I. labiatus* appears above the base of the 'Craie marneuse' in the type area.

Many of the problems concerning the definition of the base of the Turonian have been solved using the foraminifera. The change from a Rotalipora/Praeglobotruncana fauna in the Cenomanian to a Praeglobotruncana/Dicarinella fauna in the Turonian can be recognised worldwide. This faunal change occurs within the Plenus Marls in the British Isles and is taken to mark the Cenomanian/Turonian boundary (Carter & Hart 1977). Praeglobotruncana helvetica (Bolli 1945) is widely regarded as the index species for the Turonian and has recently been recorded from the type area (Robaszynski et al. 1982).

Butt (1966) described the foraminifera from a Turonian section in the Cher Valley which included Dicarinella hagni (Scheibnerova 1962), Hedbergella delrioenensis (Carsey 1926) and Praeglobotruncana stephani (Gandolfi 1942). This is the same assemblage as that recorded from the "Sables de Bousse" and the "Craie à Terebratella carantonensis". Therefore, Lecointre's (1959) interpretation that these were lateral facies variations of the basal Turonian was correct.

3.2.3. Coniacian

D'Archiac (1836) divided the stratigraphic succession of Dordogne and Charente (Aquitaine), Western France into units based solely on lithology. Subsequently, Coquand (1856) set up a nomenclatorial framework based on d'Archiac's divisions and in 1857, Coquand revised his work in Charente and used palaeontological criteria, together with lithological and mineralogical characteristics, to define the Coniacian, Santonian and Campanian stages. The type locality designated for the Coniacian is near Cognac (Charente) in the northern part of the Aquitaine Basin.

The validity of Coquand's three stages was first questioned by Arnaud (1878), but research on the Coniacian was then largely neglected until Seronie - Vivien (1956) restudied the sequences and faunas of the type area.

The basal part of the type section at Cognac comprises glauconitic sands with no fossil of stratigraphic value, lying unconformably on Turonian strata (Seronie - Vivien 1972). Therefore, the definition of the base of the Coniacian is problematic. The stratotype consists of both clastic and carbonate facies that yield rare ammonites with rudist bivalves and orbitoid foraminiferans in the upper part (Seronie - Vivien 1980a). The faunas can be used to establish an almost world-wide correlation (Rawson et al. 1978) but not with the white chalk facies of the Anglo-Paris Basin where these particular groups are rare or absent. The base of the stage is generally defined at the base of the 'Craie de Villedieu' Formation (Rawson et al. 1978; Jarvis et al. 1982). According to the macrofauna, it is identified by the appearance of the ammonites Tissotia, Barroisiceras and early texanitids which occur in the lowest member of the 'Craie de Villedieu'. Two ammonite zones are recognised in the Coniacian (de Grossouvre 1895-1901; Sornay 1957; Rawson et al. 1978):-

Paratexanites emscheris Zone

Barroisiceras haberfellneri Zone

The type sections of the 'Craie de Villedieu' lie in the south-west Anglo-Paris Basin and are of stratigraphic importance because of their lithological and faunal similarity to the Coniacian and Santonian stratotypes in the Aquitaine Basin. Recent lithostratigraphical and

biostratigraphical studies of the type sections have shown the 'Craie de Villedieu' to contain ammonites, Micraster, inoceramids (species which are known from the Chalk of south-east England) and other taxa which enable a more precise correlation between Aquitaine and the Anglo-Paris Basin than has been previously possible (Jarvis et al. 1982).

Ammonites are scarce at this level in the British successions and therefore direct correlation with the stratotype is very difficult. Correlation is dependent on other faunal groups and the British Coniacian is divided into two echinoid zones (Stokes 1975):-

Micraster coranguinum Zone (pars)
Micraster cortestudinarium Zone

The microfauna of the British Coniacian has been examined by Bailey (1975; 1976 (unpubli); Hart et al. (1981) and most recently by Bailey et al. (1983). Two named foraminiferal biozones based on evolutionary changes within the genus Stensioeina have been proposed:-

Stensioeina exsculpta exsculpta Zone (partial range zone)
Stensioeina granulata granulata Zone (partial range zone)

These zones are believed to be readily applicable in Europe generally (Bailey et al. 1983).

3.2.4. Santonian

The Santonian was one of three substages proposed by Coquand (1856) and later upgraded to the rank of stage (Coquand 1857). It was named after the village of Saintes in the Charente Valley (Charente Maritime), Western France. Coquand (1858) designated a section on the road between Jauresac and Saintes as type, but a number of other sections in 'soft chalk with flints' were mentioned in a course of papers by Coquand, not only around Saintes but in the valley of the Dronne (Charente). In general, the sequence comprises yellowish-white marly chalks, bryozoan-rich chalks and limestones with flints, with hardgrounds and oyster beds at some levels.

Similar problems to those experienced in correlating the British Coniacian with its stratotype by means of the macrofauna (see 3.2.3. above) are also encountered with the Santonian. The macrofauna of the Santonian stratotype is rich and varied but generally poorly preserved; it allows an almost worldwide correlation but, as with the Coniacian, not with the white chalk facies of the Anglo-Paris Basin.

De Grossouvre (1895, 1901) recognised two ammonite zones in the Santonian:-

Placenticeras syrtale Zone

Texanites texanus Zone

Both of the zonal indices have been recorded from the immediate vicinity of Saintes (Séronie - Vivien 1972) but in the stratotype area, the base of the Stage cannot be defined faunally.

As ammonites are rare or absent in the British Santonian, the zones currently used are based on echinoderms:-

Micraster testudinarius Zone

Uintacrinus socialis Zone

Micraster coranguinum Zone (pars)

Direct correlation with the stratotype is thus very difficult. However, the recent lithostratigraphical and biostratigraphical study of the type sections of the 'Craie de Villedieu' Formation, south western Anglo-Paris Basin, Western France, have revealed biostratigraphically important groups known from the Santonian stratotype in Aquitaine together with those known from the Chalk of northwest Europe; the succession is ammonite-bearing and yields species of echinoids and inoceramids known from the Chalk. Thus this formation has great potential value as a key for correlation (Jarvis et al. 1982).

Microfaunally, the Santonian of the British Isles is quite distinctive and many zonally important planktonic foraminifera have been recorded (Bailey 1978 (unpubl.); Hart et al. 1981). Three named foraminiferal biozones based on evolutionary changes within the genera *Stensioeina* and *Bolivinoides* have recently been proposed for the stage (Bailey et al. 1983). These are:-

Bolivinoides strigillatus Zone (partial range zone)

Stensioeina granulata perfecta Zone (partial range zone)

Stensioeina granulata polonica Zone (total range zone)

These zones are believed to be readily applicable in Europe generally.

3.2.5. Campanian

Following his work in the Charente region of southwest France, Coquand (1856) described a rock unit of marls, chert and soft chalk containing the oyster Ostrea vesicularis, which he later attributed to the Campanian stage (Coquand 1857). He designated as type, the section at Aubeterre - Sur - Dronne (La Grand Champagne - hence Campanian) in Charente (Coquand 1858). In recent years, this section has been studied in detail by many geologists (e.g. van Hinte 1965; 1966; 1967; 1979; Goharian 1971; van Gorsel 1973).

Coquand's original description of the section at Aubeterre recorded the Campanian overlying the Saintes Formation (Santonian). However, the lowest accessible beds yield Ostrea vesicularis and therefore are by definition still part of the Campanian (Goharian 1971). Subsequent investigations of the two sections in the Champagne region, recorded by Coquand as Campanian, have shown them to be not exact time equivalents and have also shown that the lower part of the Campanian is absent at Aubeterre (Séronie - Vivien 1972). Thus, Coquand was mistaken when he recorded the presence of the Campanian-Santonian contact in the type area (van Gorsel 1973). Work on the foraminifera of the type section has also shown the Lower and Middle Campanian to be absent (van Hinte 1962; 1965; 1966; 1967; Séronie - Vivien 1972; Sweicicki 1980 (unpubl.)). Clearly it is not possible to define the base of the stage

from the stratotype. In fact, work on the microfauna has shown that the bulk of the type Campanian at Aubeterre actually belongs to the Maastrichtian stage as now understood (van Hinte 1965; Goharian 1971; Séronie - Vivien 1972; see 3.2.6. below).

The meaning of the Campanian stage is thus at present open to misinterpretation. Despite the designation of parastratotype sections near Ne in Charente (Séronie - Vivien 1972), the scarcity and indistinctive character of the macrofauna has meant that there is still no working standard for the base of the stage.

De Grossouvre (1895-1901) recognised possible ammonite zones and the following are in current use:-

Bostrychoceras polyplocum Zone
Hoplitoplacenticeras vari Zone
Delawarella delawarensis Zone
Placenticeras bidosatum Zone

Marked provinciality of the key macrofossil genera and the influence of facies control on the distribution of stratigraphically important groups of benthonic organisms have led to many problems in the correlation of the British succession with the type Campanian (Rawson et al. 1978). In Britain, the index ammonites are absent and zones based on belmnites and echinoids are currently used. These are:-

Belemnitella mucronata Zone

Gonioteuthis quadrata Zone

Offaster pilula Zone

The microfauna of the type sections is, like the macrofauna, poor and correlation with other areas is difficult. The foraminifera of the British Campanian have recently been examined (Sweicicki 1980 (unpubl.); Hart et al. 1981) and two named foraminiferal biozones have been proposed (Bailey et al. 1983).

Bolivinoides decoratus Zone (pars) (partial range zone)

Bolivinoides culverensis Zone (total range zone)

However, these two biozones do not represent all of the Campanian (only the pilula Zone, quadrata Zone and part of the mucronata Zone).

3.2.6. Maastrichtian

Within the Upper Cretaceous of Limburg, Holland, Dumont (1832) recognised two major lithostratigraphic subdivisions which he called 'craie' and 'calcaire de Maestricht'. In 1850, he formally proposed the Maastrichtian stage and renamed his two previously described lithostratigraphic units 'Systeme Senonien' and 'Systeme Maestrichtian' respectively. However, Dumont's original concept of the Maastrichtian appears vague and there is more controversy about its precise limits (discussions in Voight 1956; Berggren 1964; Deroo 1966). Van der Heide (1954 pp. 509-511) maintained that Dumont's original definition included only the 'Tuffeau de Maestricht' and that the 'Systeme Senonian' referred to the underlying Glauben Chalk. The Maastrichtian

stratotype has been designated by the 'Comité d'étude de Maastrichtian' as the sequence of tuffaceous chalk exposed in the large E.N.C.I. quarry at St. Pietersberg on the outskirts of Maastricht in Holland from which the Stage takes it's name. However, this type Maastrichtian corresponds to only the upper part of the Maastrichtian of current usage.

Much of the confusion concerning the limits of the stage results from the fact that the type section shows a warm water detrital facies which is of only local significance compared to the typical white chalk facies encountered elsewhere in Europe.

Recent work on the belemnite succession of the white chalk facies has led to a revision of our understanding of the stage and its base is now taken at a level below that of Dumont's original definition (Jeletzky 1951; Birkelund 1957; 1966; Schmid 1959; 1967). The presence of hardgrounds means that there are breaks in the belemnite succession and this has caused problems for the macrofossil zonation throughout Europe (e.g. Schmid in Schmid et al. 1955). The Maastrichtian _____ is regarded as being co-extensive with the range of the ammonite Scaphites (Hoploscaphites) constrictus; the appearance of the belemnite Belemnella lanceolata marks its base. However, some geologists consider that the base of the Maastrichtian is identified by the appearance of ammonite S. (H.) tenuistriatus and that S. (H.) constrictus appears higher up in the Lower Maastrichtian (e.g. Birkelund 1966).

The Maastrichtian is generally absent from the British Isles where it is known only from the glacially transported masses in the Pleistocene drift of the Norfolk coast and from the highest preserved level of the White Limestone of Northern Ireland. Both localities have incomplete successions and the entire Upper Maastrichtian is missing. Zones based on belemnites, (Schmid 1967; Rawson et al. 1978) which have been used for these sequences are:-

Belemnella occidentalis Zone

Belemnella lanceolata Zone

Microfaunal investigations have provided a good zonation scheme for the Maastrichtian (e.g. Hiltermann 1952; Hiltermann & Koch 1955; Berggren 1960; 1962 (a); 1962 (b); Hofker 1962; 1964; Koch 1977; Swiecicki 1980 (unpubl.); 1981; Hart et al. 1981).

3.3. Danian and the Cretaceous - Tertiary Boundary

Desor (1846) proposed the establishment of a Danian Stage (the 'terrain danien') based on its typical development on the islands of Denmark. In 1847, he included the Danian with the Upper Cretaceous because of its lithological similarities, stratigraphical position and echinoid fauna. This was supported by d'Orbigny (1852), but apparently on the basis of the mistaken idea that it contained species of Baculites and Belemnitella.

Following his work on the molluscan fauna, Frochhammer (1825) had earlier assigned these strata to the Tertiary and this idea was given strength by Grossouvre (1897).

Modern palaeontological investigations of the Danian began with Ravn's (1902-1903) monograph on the Mollusca of the Danian chalk in which he concluded that the Danian represented the youngest part of the Cretaceous. However, in 1919, Brunnich-Nielsen described a Danian hydrocoral fauna from Fakse which had affinities closer to Tertiary rather than Cretaceous faunas and he therefore suggested that the Danian in fact represented the oldest part of the Tertiary. This idea was supported by Besrukov (1934, 1936) on the basis of his field and palaeontological studies on the Danian of the Ural River in the USSR.

The justification for assigning the Danian to the Cretaceous is that there is continuous carbonate sedimentation in northwestern Europe from the Maastrichtian into the Danian and many taxa of bryozoa, echinoids, brachiopods, bivalves and gastropods of Cretaceous aspect continue to the end of the Danian (Currey et al. 1978). However, the top of the Maastrichtian is marked by the final disappearance of plesiosaurs, mosasaurs, ammonites, rudist bivalves and several genera of larger foraminifera, and the near extinction of the planktonic foraminifera and the nannoplankton. The marked generic change in the planktonic foraminiferal assemblages between the Maastrichtian (Globotruncana - Heterohelix assemblage) and the Danian (small globigerinids and non-keeled globorotaliids) (Berggren 1962 (a); 1962 (b); 1964; Bang, 1971, 1972), coupled with the other faunal changes mentioned above strengthens the case for placing the Danian in the Tertiary.

In a number of papers, Hofker (e.g. 1962) correlated the type Danian with the type Maastrichtian using the foraminifera. However, the type Danian and type Maastrichtian cannot be correlated with each

other (Hancock 1972) using the macrofauna and Berggren (1964) subsequently showed that Hofker had mis-interpreted many of the foraminifers.

It is now almost universally agreed that Danian strata represent the oldest part of the Tertiary and they are assigned to the Palaeogene.

The marked change in the fauna at the Cretaceous - Tertiary boundary has provoked many speculative ideas about global events which might have caused a major crisis for Cretaceous flora and fauna resulting in 'mass extinctions'. These ideas invoke changes in sea-level, nutrient depletion, climatic deterioration (e.g. Archibald 1981) palaeooceanographic events (e.g. Thierstein & Berger 1978), and a terrestrial catastrophe caused by the impact of a comet (e.g. Alvarez et al. 1980; Hsu 1980; Surlyk 1980; Smit & Hertogen 1980; Archibald 1981). Evidence for these speculations is taken from oxygen-carbon isotope ratios (e.g. Romein & Smit 1981), magnetic reversals and palaeontological observations (e.g. Archibald 1981).

However, many geologists (e.g. Hancock 1967) do not believe that prominent groups of animals with a world wide distribution suddenly and simultaneously became extinct at the end of the Maastrichtian. Many of the statements regarding 'mass extinction' appear to be based on incomplete evidence; for example, the ammonites and belemnites which are known as fossils diminish in variety, geographical range and numbers of individuals before the end of the Cretaceous, probably partly as a response to the seas becoming shallower and more widespread non-marine sedimentation. Although a number of faunal/floral

disappearances or near disappearance do occur within a relatively short period of geological time, these need not be explained by a catastrophic event limited in time to a few thousand years. The subject remains a much discussed and controversial topic.

3.4. Upper Cretaceous chronostratigraphic scale

The six stages of the Upper Cretaceous (as discussed above) are listed in Figure 3.2. with radiometric dates taken from Harland et al. (1982). The figure demonstrates clearly the disparate time duration involved for the individual stages - from about one million years for the Coniacian to ten million years for the Campanian. The Cretaceous time-scale proposed by van Hinte (1976) based on published Cretaceous radiometric age determinations plotted against a relative geological time scale is also shown. Both schemes agree on a time span of approximately thirty to forty million years for the Late Cretaceous.

SYSTEM	SERIES	STAGE	RADIOMETRIC AGE IN MILLIONS OF YEARS
PALEOGENE	PALEOCENE	DANIAN	* Harland et al. 1982. + van Hinte 1976 65* 65+
CRETACEOUS	UPPER	MAASTRICHTIAN	
		CAMPANIAN	73* 70+
		SANTONIAN	83* 78+
		CONIACIAN	87.5* 82+
		TURONIAN	88.5* 86+
		CENOMANIAN	91* 92+
	LOWER	ALBIAN	97.5* 100+ 113* 108+

Fig. 3.2 Upper Cretaceous chronostratigraphic scale

CHAPTER 4

LABORATORY TECHNIQUES

4.1. Introduction

The sampling methods and processing techniques employed in any micropalaeontological investigation will affect the quality of the results obtained, as both may introduce a bias which will influence the final results and conclusions. Therefore in any study, it is desirable to treat all the samples in the same way in order to achieve consistency. However, this is not always possible because of the differences in the physical properties of the samples which depend on the chemical composition and diagenetic history. In the present study, the nature of the material allowed a single processing technique to be applied to all samples. At least, therefore, any bias introduced at this stage is consistent for all samples.

4.2. Nature of the samples

The borehole samples used in the present study (provided by Shell UK Exploration and Production Ltd.) are "ditch cuttings", which are tiny chips of rock cut by the drill bit. These are brought to the surface by drilling mud that is circulated to lubricate the drill bit and to prevent the well caving in. The problems introduced by using ditch cuttings in a detailed biostratigraphic study are many and an awareness of the restrictions imposed by these samples is necessary.

The cuttings are collected at the surface after being separated from the drilling fluids by vibrating sieve screens or "shale shakers". In order to assign the correct depth to a sample of cuttings, the time

between the drilling of the rock at the bottom of the hole and its arrival at the surface (the lag-time) has to be calculated accurately. This is done by circulating a "tracer" in the mud system, or by registering the number of strokes the mud pumps require to bring the cuttings to the surface.

The total material to arrive at the surface is an aggregate of the sample interval which, in the present study, is generally 30ft., but occasionally 10ft.

To obtain a representative sample of this total sample interval, the cuttings have to be collected over a period of time, i.e. from the first foot of sample arriving at the surface, to the last foot. The time this takes is governed by the rate of penetration. This rate affects the degree of accuracy to which each sample can be placed in the formation. If the rate of penetration is slow, the interval may be sampled progressively; if the rate of penetration is fast, cuttings are allowed to accumulate over the whole sample interval and a representative sample is then taken, which is therefore likely to be less accurate. Very small samples are unlikely to be accurate representatives of a complete 30ft. sample interval.

The collected cuttings are washed to remove the mud and are split into three fractions: >5 mm, 0.5 - 5 mm and <0.5 mm.

A further complication is that of "cavings". This is material introduced into the mud system from younger stratigraphic levels higher up the well. Cavings tend to be larger than cuttings, so many occur in the >5 mm fraction which is therefore usually ignored. The <0.5 mm

fraction is largely recirculated material and is also ignored. Thus by taking cuttings from only the 0.5 - 5 mm fraction, hopefully most of the contamination is removed.

The author was not present at the time of sample collection, so it is impossible to assess in detail the specific inaccuracies involved.

4.3. Processing

The four major methods which have been developed for extracting calcareous microfossils from a chalk matrix are:-

(i) boiling in hydrogen peroxide
(ii) disaggregation in white spirit
(iii) Glauber's salt crystallisation
(iv) physical crushing

These methods have been described by several authors, e.g. Williams-Mitchell 1948; Barr 1961; Owen 1970 (unpubl.); Swiecicki 1980 (unpubl.); Weaver 1982.

Some of the methods involve harsh treatment and may destroy the most fragile (i.e. the planktonic) element of the fauna, thereby giving a residue apparently dominated by the more robust benthonic foraminifera. Care must therefore be taken during processing and, if possible, the least destructive method (i.e. disaggregation in white spirit) should be used. Fortunately, in the present study the chalk was relatively soft because it contained a substantial proportion of clay minerals, and the white spirit method was possible for all samples.

The samples had already been washed, sieved and dried on site at the time of drilling (see paragraph 4.2). In many studies, the samples would then be weighed so that the subsequent foraminiferal yield could be related in general terms to sample size. However, in the present study, the chalk samples were not weighed because of the persistent but variable flint content which would make the weight of the sample unreliable as an indicator of sample size.

Each dried sample was covered with white spirit and allowed to soak for one hour. The white spirit was then poured off and cold water added. The sample was then left for several hours until it was disaggregated. The disaggregated sediment was then gently washed through a 75 μm sieve, dried in an oven and stored in a glass tube.

The processing history of the samples used in the study is summarised in Fig. 4.1.

4.4. Sample examination

The dry residue from each sample was split into four size fractions in a nest of sieves (500 μm, 250-500 μm, 180-250 μm, 125-180 μm). The 500 μm fraction was picked completely for foraminifera. When possible at least 300 foraminifera were picked from each of the 250-500 μm and 180-250 μm size fractions, and the remainder of these fractions checked for unusual forms; small samples would often have been picked clean. The 125-180 μm size fraction was examined only briefly because of the high proportion of juvenile forms.

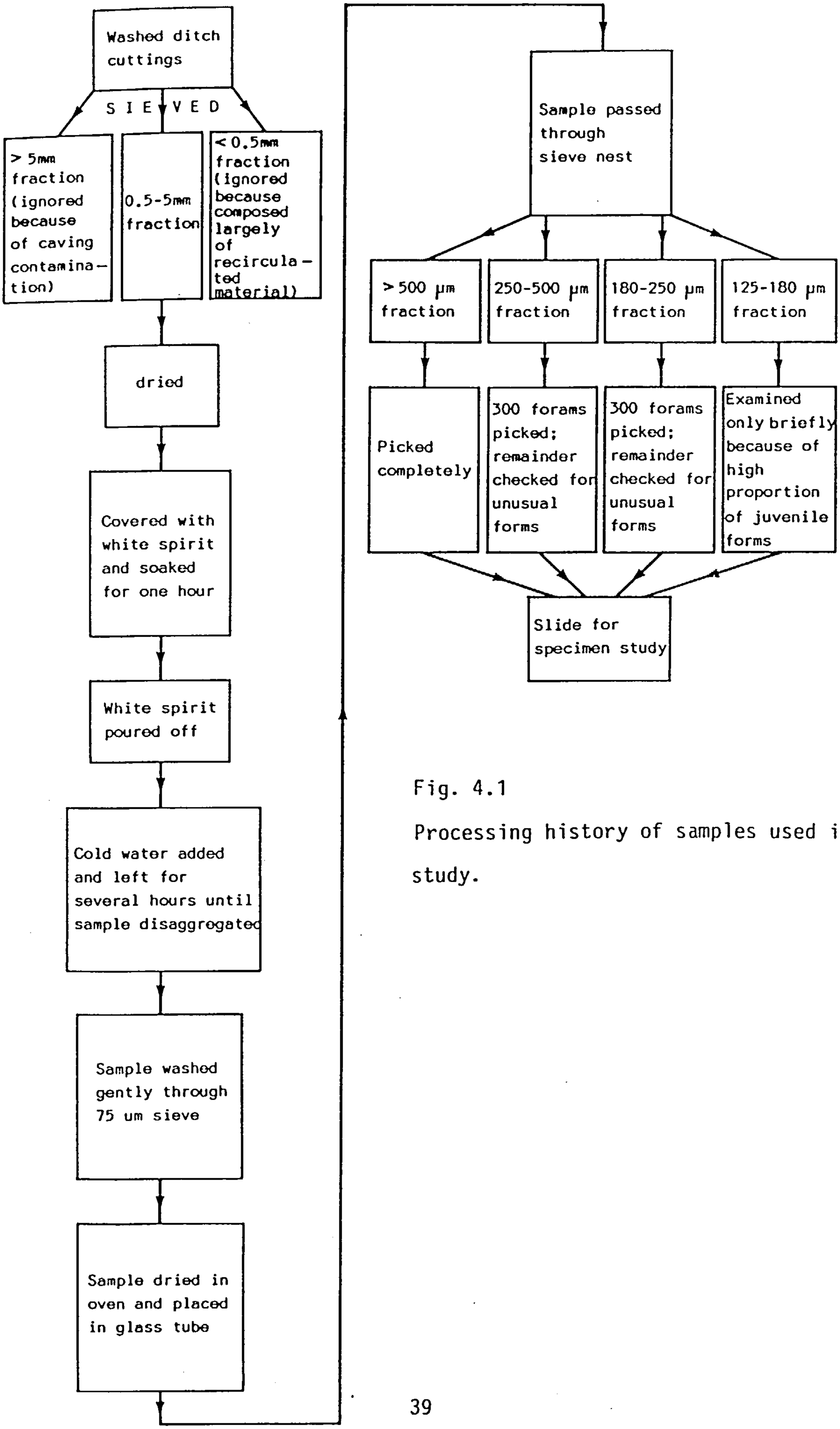

Fig. 4.1

Processing history of samples used in this study.

4.5 Specimen study

All the specimens were examined using a stereomicroscope at x120 - x1000 magnification. Those specimens which were selected for illustration were mounted on scanning electron microscope stubs using double-sided tape, the adhesive of which had been thinned using xylene. The mounted specimens were "sputter coated" with approximately 100 Å.U. of gold and then photographed on an I.S.I. 60 scanning electron microscope. Measurements of these figured specimens were made using a graduated eyepiece in the stereomicroscope or directly from the SEM photographs.

CHAPTER 5

LITHOSTRATIGRAPHY

5.1. Lithologies and depositional history

The Southern North Sea Basin is one of the bulkiest Upper Cretaceous basins in Europe with sediment thicknesses generally of at least 400 m. The greatest thicknesses (more than 1600 m) are reached on the southwest flank of the Central Netherlands Inversion and to the southwest of the Central Graben Inversion (Hancock and Scholle 1975) (Fig.2.3). The sediments are almost entirely of chalk facies which blankets earlier surface irregularities and grades northwards (north of latitude 59° 30') into calcareous shales and silts in the Viking Graben (Rawson et al. 1978).

Chalk is a very fine-grained, friable limestone or biomicrite which represents an accumulation of the skeletons and tests of foraminifera, calcispheres, bivalve fragments (notably Inoceramus), echinoid plates and bryozoa, together with sponge, brachipod, belemnite and ammonite fragments. However, the dominant constituent are the skeletal plates (coccoliths) of planktonic brown algae (Haptophyceae). Non-carbonate components include quartz, glauconite and phosphatic flecks (Hancock 1976).

This unusual and unique deposit resulted from the existence of a vast epicontinental sea and an associated availability of a diversified calcareous fauna. The sea bottom was probably soft mud - many of the fossils found in the chalk show adaptations to a soft substrate. For instance, the bivalves are often spinose, the left valves of the

inoceramids are generally inflated to elevate the feeding area, and brachiopod pedicles are often seen to branch into rootlets which increase the efficiency of anchorage (Hancock 1976).

The Upper Cretaceous sediments of Europe were deposited over Pre-Cambrian and Palaeozoic massifs which, except for certain areas such as those now occupied by the Scottish Highlands and parts of Scandinavia, were submerged during the Late Campanian when sea level reached a maximum. The availability of land areas as a source for terrigenous input was therefore very limited and, as a result, chalk is a very pure deposit. Pure chalk is thought to have been deposited most generally at a water depth of 200m - 300m, but may be up to 1000m and seldom less than 80m. The Southern North Sea Basin was already submerged when chalk deposition started in the Cenomanian and water depths in this region are believed to have been considerable; deeper water chalk facies predominate (Hancock and Scholle 1975).

Much of the chalk of the Southern North Sea Basin is hard limestone, similar to that seen on the Yorkshire coast. This is a diagenetic effect resulting from the weight of overburden, local tectonic stresses and/or high heat flow (Neugebauer 1974; Scholle 1974; Hancock 1976; Hancock 1981).

The deposition of the chalk lasted some 30 million years and occurred over several continents. Today it is of economic importance as a reservoir rock in the Dan and Ekofisk oil fields.

A characteristic feature of European chalk sequences is the presence of flint which occurs in bands along bedding planes, as late stage diagenetic infills along jointing and in fossil replacements. Flint is a variety of chert and is composed of micron-sized, randomly arranged quartz crystals. It has a conchoidal fracture and a grain size of 2-30

μm (Michelsen 1966; Anderton et al. 1979). The origin and formation of marine chert has long been a controversial topic, but it seems that it is a result of both early and late stage diagenetic processes (Voigt 1981). The first stage of flint formation involves the precipitation of low termperature cristobalite around sites of organic decay. Later diagenesis due to deeper burial causes the transformation of cristobalite to chalcedonic quartz (flint) (Wise and Weaver 1974). It is generally agreed that the component silica had a biogenic origin; cherts contain recognisable siliceous fossils thereby dispelling the need for exotic theories concerning the source. Some small contribution from a volcanic source seems likely because of the association of devitrified volcanic glass and montmorillonite with greenish-grey cherts (Keene 1975). The site of chert formation is controlled by the texture and composition of the sediment. Silicification preferentially occurs in permeable, porous sediments which in the chalk carbonate environment are provided by a high formainifera to nannofossil ratio, and in a clayey environment by radiolarian-rich layers. A high organic content in the sediment may also favour chert formation (Keene 1975). An association between nodular flint horizons and Thalassinoides burrow systems has been noted Bromley (1967), Bromley et al. (1975) and Kennedy and Garrison (1975). These deep burrow systems introduced organic-rich material to a depth in the sediment where other organic material had been removed by various burrowing organisms and aerobic decay. Rhythmic nodular flint horizons were produced as a result of the precipitation of silica controlled by the chemical gradients set up by the introduction of organic material to these depths.

In the boreholes used in this study, the chalk is mainly white to greyish-white in colour and varies from friable to moderately hard. As well as yielding foraminifera and ostracods, the samples also contained echinoderm fragments, inoceramid prisms, bryozoa and sponge fragments, and microbrachiopods. Flints are particularly common in the upper half

of the boreholes where they predominate over chalk in the ditch cuttings. The flints range in colour from grey, blue-grey, white to grey-white. With detailed work on core material, it may be possible to erect a detailed stratigraphical standard using the occurrence of these fossils together with the flints; such a scheme is being considered for onshore sections (pers. comm. C.J. Wood). However, in the present study, the fact that each sample represented 30 ft. of strata coupled with the problem of cavings, has meant that such a detailed and integrated approach has not been possible.

5.2. Geophysical methods of correlation

A major tool in the analysis and correlation of offshore lithological sequences is the geophysical borehole log. Used in conjunction with seismic surveys and the examination of core (when available) and/or ditch cuttings, it is possible to correlate one borehole with others in the vicinity and even across hundreds of kilometres. Logging companies run a variety of logs which measure different geophysical properties of the rocks penetrated in the well; these are run after the completion of drilling. Amongst the most commonly used types are the Gamma Ray Log and the Formation Density Log.

The Gamma Ray Log is a nuclear logging system which measures the natural radioactivity of the rock sequence. The log signature shows the gamma-activity of the rock recorded against the depth. The natural radioactivity commonly recorded is the isotope potassium-40 which is concentrated in clay minerals. The radioactivity logged by the Gamma Ray Log generally indicates the shale content of the rock. It is measured in standard American Petroleum Institute (API) units. More than 75 API units usually indicates a shale, and less than 75 API units usually indicates a sandstone (Schlumberger 1972). Organic-rich shales

often have a concentration of radioactive elements; these are characterised by particularly high (80-160 API units) gamma ray responses e.g. the Plenus Marl.

The Formation Density Log is a radioactive logging system measuring the porosity of the rock sequence. A radioative source is applied to the hole wall which emits gamma rays into the formation. The gamma rays 'collide' with the electrons in the formation, losing some, but not all of their energy at each collision, then continue with diminished energy; this is known as Compton scattering. The number of Compton scattering interactions depends directly on the number of electrons in the formation (i.e. the electron density). This is related to the true bulk density in gms/cc, which itself depends on the density of the rock matrix material formation porosity and the density of the pore fluids; 2.2-2.65 gms/cc usually indicates a shale or clay and 2.65-2.68 usually indicates a sandstone or quartzite (Schlumberger, 1972).

By studying the log signatures, different lithological units and formation boundaries are recognised by picking out characteristic inflections. Many of the peaks have characteristic shapes and some groups of peaks always return in the same stratigraphical sequence. By relating these to type and reference well sections (and to core and ditch cuttings), the lithological sequence may be interpreted and the different wells correlated.

Gamma Ray Logs and Formation Density Logs (Gamma Ray only for Shell 44/2-1 and only part of the Formation Density Log for Shell 49/19-1) were provided for the wells used in the present study. The Gamma Ray signatures are very regular emphasising the uniform nature of the chalk lithology and the lack of terrigenous material. The Formation Density Log signatures are more irregular, probably resulting from alternations of soft and hard chalk, and the presence of flints. A very distinctive

log feature occurs near the base of the sequence - there is a pronounced decrease in the gamma ray radiation and an associated dramatic increase in the true bulk density. These sorts of signatures are indicative of a mudstone which is here interpreted as the Plenus Marl or equivalent.

In the present study, the evidence from the cuttings and the log signatures allows only a broad subdivision of the sequences, and stratigraphical conclusions rely heavily on the foraminifera.

5.3. Offshore Upper Cretaceous lithostratigraphic nomenclature

To facilitate easy communications between and amongst scientists and industry, standard lithostratigraphic nomenclature has been proposed for the U.K. Southern (Rhys 1974), Central and Northern North Sea Basin (Deegan and Scull 1977). A standard lithostratigraphy has also been proposed for the Dutch sector of the North Sea Basin (NAM and RGD 1980). For the Upper Cretaceous, both the U.K. and Dutch schemes utilised data from offshore and onshore boreholes and published data on the onshore outcrop stratigraphy. Subsequently, Burnhill and Ramsay (1981) discussed mid-Cretaceous lithostratigraphy and the electric log characteristics of each lithostratigraphic unit of the U.K. Central North Sea Basin as defined by Deegan and Scull (1977).

Thus, there are two lithostratigraphic schemes for the Upper Cretaceous of the Southern North Sea Basin which exist because of an international territorial boundary (U.K./Netherlands); they do not reflect an actual geological distinction. The Dutch scheme is well established and is a viable tool for hydrocarbon exploration used by the Nederlandes Aardohe Maatschuppij B.V. since 1949. However, the U.K. scheme has not been used extensively in exploration of the British Southern North Sea Basin and its terminology has not become entrenched in the literature.

The well section designated as type for the Upper Cretaceous of the U.K. Southern North Sea Basin is Shell 49/24-1 (Fig.5.1). For the chalky limestones that make up the upper part of the Cretaceous succession, the name Chalk Group was proposed, although lithological information is not detailed enough at present to enable subdivision into formations. The base of the Chalk Group rests on the Red Chalk Formation of the Cromer Knoll Group. The junction can be recognised in the type well log by a marked decrease in gamma-ray radiation and an associated distinct increase in the true bulk density gms/cc. A similar log signature also marks the boundary of the Chalk Group with the overlying Palaeocene mudstones. No Plenus Marl was proved in the type well section.

As the Cretaceous and Danian sediments of the Central North Sea are generally similar to those of the Southern North Sea Basin, the name Chalk Group is also used for these sediments in that area (Deegan and Scull 1977). Subtle lithological changes reflected by wire-line log traces are recognised within the Chalk Group and a number of formations are differentiated. Towards the edge of the basin, argillaceous intercalations provide a basis for further subdivision (Fig.5.2). Danian strata in the Central North Sea Basin are highly calcareous and comprise the Ekofisk Formation which is included in the Chalk Group. These strata are distinct from the overlying Tertiary non-calcareous clastics.

In the Northern North Sea Basin, Upper Cretaceous and Danian strata comprise an argillaceous and calcareous marine sequence for which the name Shetland Group has been proposed (Deegan and Scull 1977). A number of subtle lithological changes enabled several subdivisions (probably of formation status) to be recognised but there were insufficient wells available to demonstrate lateral continuity and no formal recommendation was made on formation nomenclature.

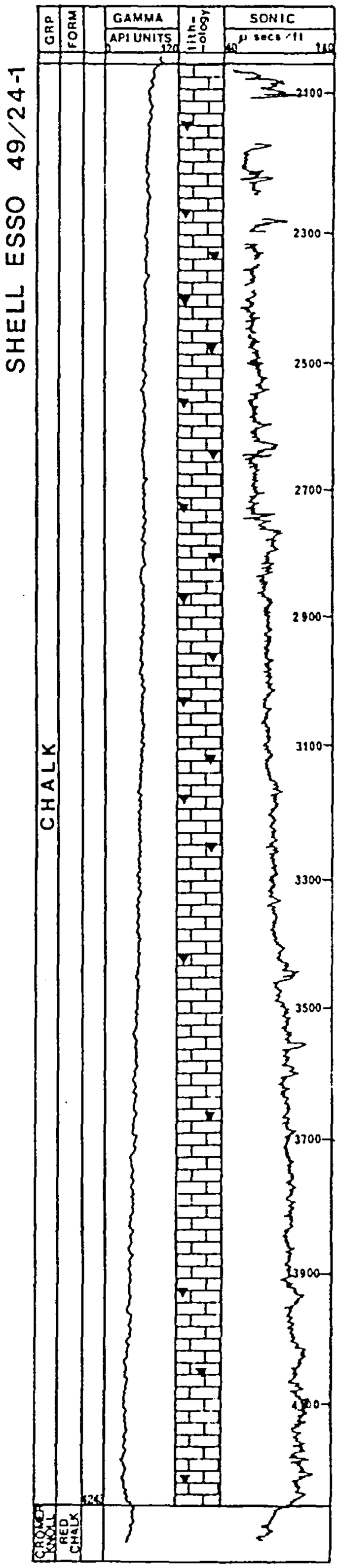

Fig. 5.1 Shell 49/24-1:
type well section for the
Upper Cretaceous of the UK
Southern North Sea Basin

Fig. 5.2 Comparison of Upper Cretaceous lithostratigraphic nomenclature in the North Sea Basin

SYSTEM	SERIES	STAGE	SOUTHERN NORTH SEA				CENTRAL NORTH SEA		NORTHERN NORTH SEA
			U.K.		DUTCH		WEST	EAST & CENTRAL	
TERTIARY	PALAEOCENE	DANIAN					EKOFISK FORMATION		SHETLAND GROUP
CRETACEOUS	UPPER	MAASTRICHTIAN	CHALK GROUP		CHALK GROUP	OMMELANDEN CHALK FM.	TOR FORMATION		
		CAMPANIAN					FLOUNDER FORMATION	HOD FORMATION	
		SANTONIAN							
		CONIACIAN					HERRING FM.		
		TURONIAN					PLENUS MARL FORMATION		
		CENOMANIAN	PLENUS MARL			TEXEL CHALK FM	HIDRA FORMATION		
	LOWER	ALBIAN	CROMER KNOLL GROUP	RED CHALK FM.	RIJNLAND GROUP	HOLLAND FM.	CROMER KNOLL GROUP	VALHALL FM. / RODBY FORMATION	CROMER KNOLL GROUP

TEXEL MARLSTONE MRB
TEXEL GREENSAND MRB
UPPER HOLLAND MARL MRB

In the standard stratigraphic nomenclature proposed for the Dutch sector of the Southern North Sea Basin, the Chalk of the Upper Cretaceous and Early Paleocene (Danian) is also included in a Chalk Group. The base of the group is taken at the base of the limestone succession which overlies the Holland Formation. It is recognised by a pronounced decrease in gamma-ray radiation and an increase in interval transit time. The top of the Group is taken at the top of the carbonates (including the Danian) below the main Tertiary sequence of sands, marls and clays. The Chalk Group described in the Dutch scheme is thus equivalent to the Chalk Group described in the U.K. scheme. The two schemes differ only in the position of the Danian - the calcareous nature of these early Tertiary strata in the Dutch sector makes it logical to include them within the Chalk Group but in the U.K. sector, they are of mudstone facies and are therefore excluded from the Group.

The Dutch scheme recognises a two fold subdivision of the Chalk Group based on the presence of a persistent basin-wide shale bed in the lower part of the Group.

There are several records of black bituminous/carbonaceous shale beds throughout the Late Cretaceous; one of these is the so-called "Black Band" of Yorkshire and Humberside. This marly horizon is associated with a complex of erosion surfaces, reworked pebbly horizons and bioturbated marls. A similar horizon is seen in S.E. England - the "Plenus Marl" (the almost biostratigraphic synonym being the now obsolete Late Cenomanian belemnite zone of Actinocamax plenus). In the past the "Black Band" was considered to be totally post-plenus in age (Jefferies 1962, 1963), although this differed from the conclusion reached by Jukes-Browne and Hill in 1903. However, after a detailed investigation of the Black Band of Yorkshire, Hart and Bigg (1981) were able to conclude that it equates with a bed or beds high in the Plenus

Marl succession of S.E. England. The Black Band of Yorkshire is the marker bed seen in the North Sea Basin, but it can now be said to be at least in part the Plenus Marl equivalent.

In the Dutch Scheme, the lower of the two subsidivions (i.e. that below the shale bed) is the Texel Chalk Formation (Cenomanian) which is a sequence of light grey chalks and marly chalks with some marl intercalations, between the base of the Chalk Group and the top of the persistent shale bed (see above). The reference well-section designated for this unit is L12-2 (NAM-CLMS) (Fig.5.3). Two members are distinguished within this formation - a basal Texel Greensand Member which occurs in the West Netherlands Basin, and the Texel Mudstone Member, a characteristically marly chalk. The Texel Chalk Formation is overlain by the Ommelanden Chalk Formation (Turonian-Danian) which is a sequence of chalks, chalky limestones and marly chalks with occasional marl intercalations. The base of the formation is taken at the top of the Texel Marl Member (if present) or by older formations, and its top by the base of the sandstones, clays and marls of the Tertiary. The designated type well for this formation is Du Paauwen-1 (Fig.5.4).

5.4. Lithostratigraphy of the boreholes used in this study

The present study involved the examination of borehole material (ditch cuttings) from three boreholes drilled by Shell (U.K.) Exploration & Production Ltd. during 1965-1971. The boreholes are all from the Southern North Sea Basin - one from the Mid-North Sea High (Shell 44/2-1) and two from the Indefatigable Gas Field (Shell 49/19-1 and Shell 49/20-2) (Fig.5.5).

L12-2 (NAM-CLM)

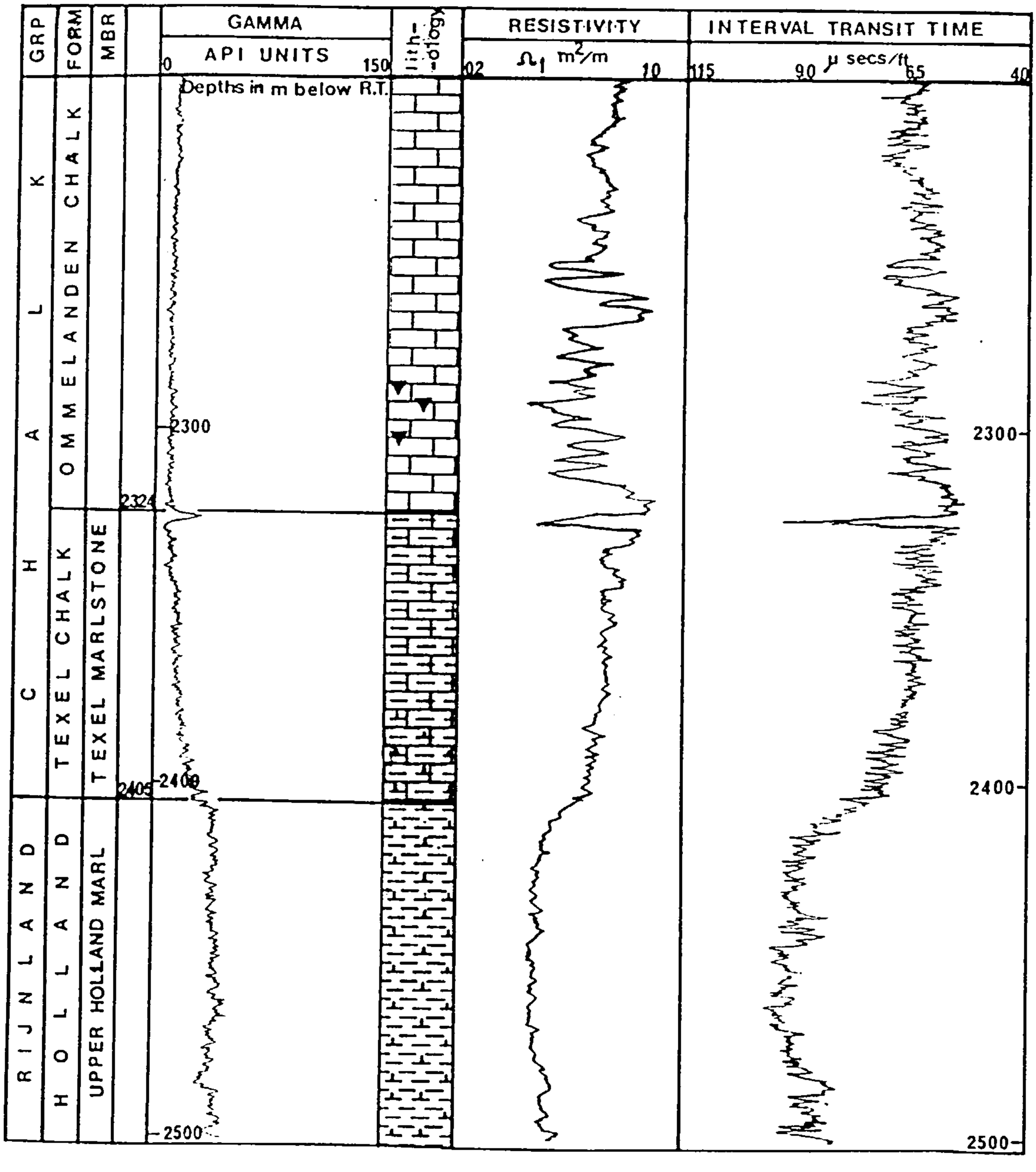

Fig. 5.3 L12-2 (NAM-CLM): type well section for the Texel Chalk Formation

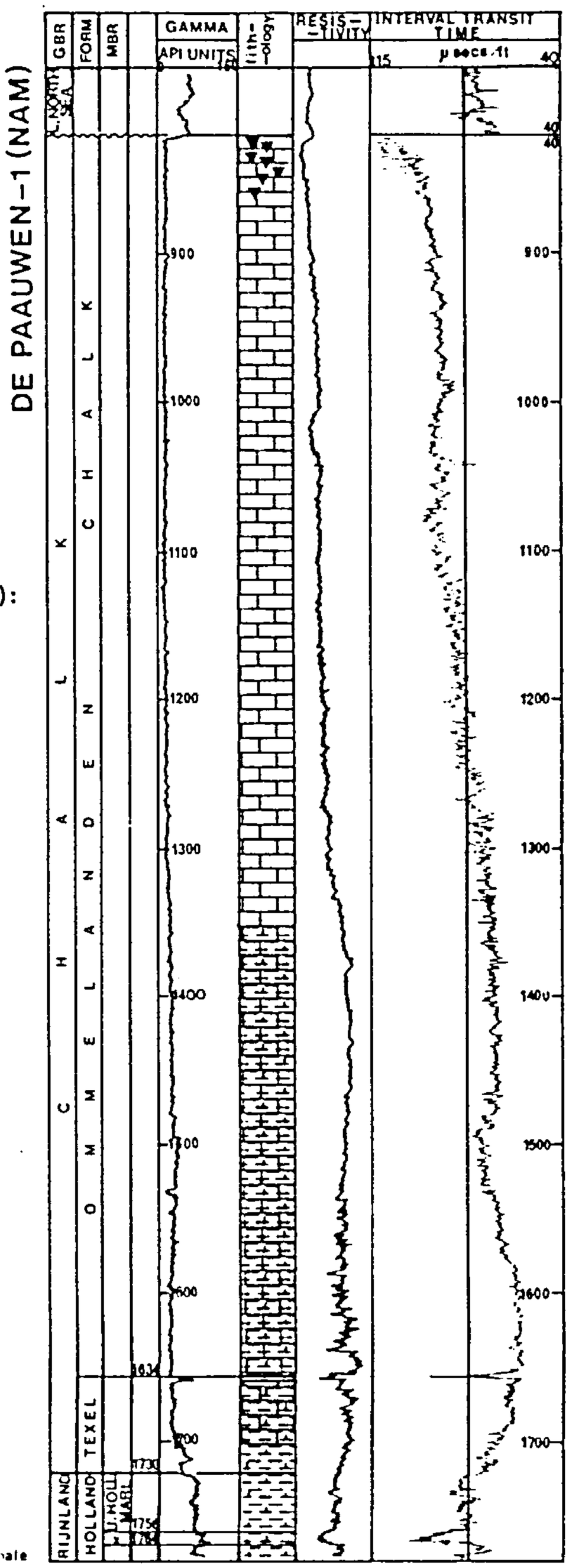

Fig. 5.4 De Paauwen-1 (NAM): type well section for the Ommelanden Chalk Formation

x = Middle Holland Shale

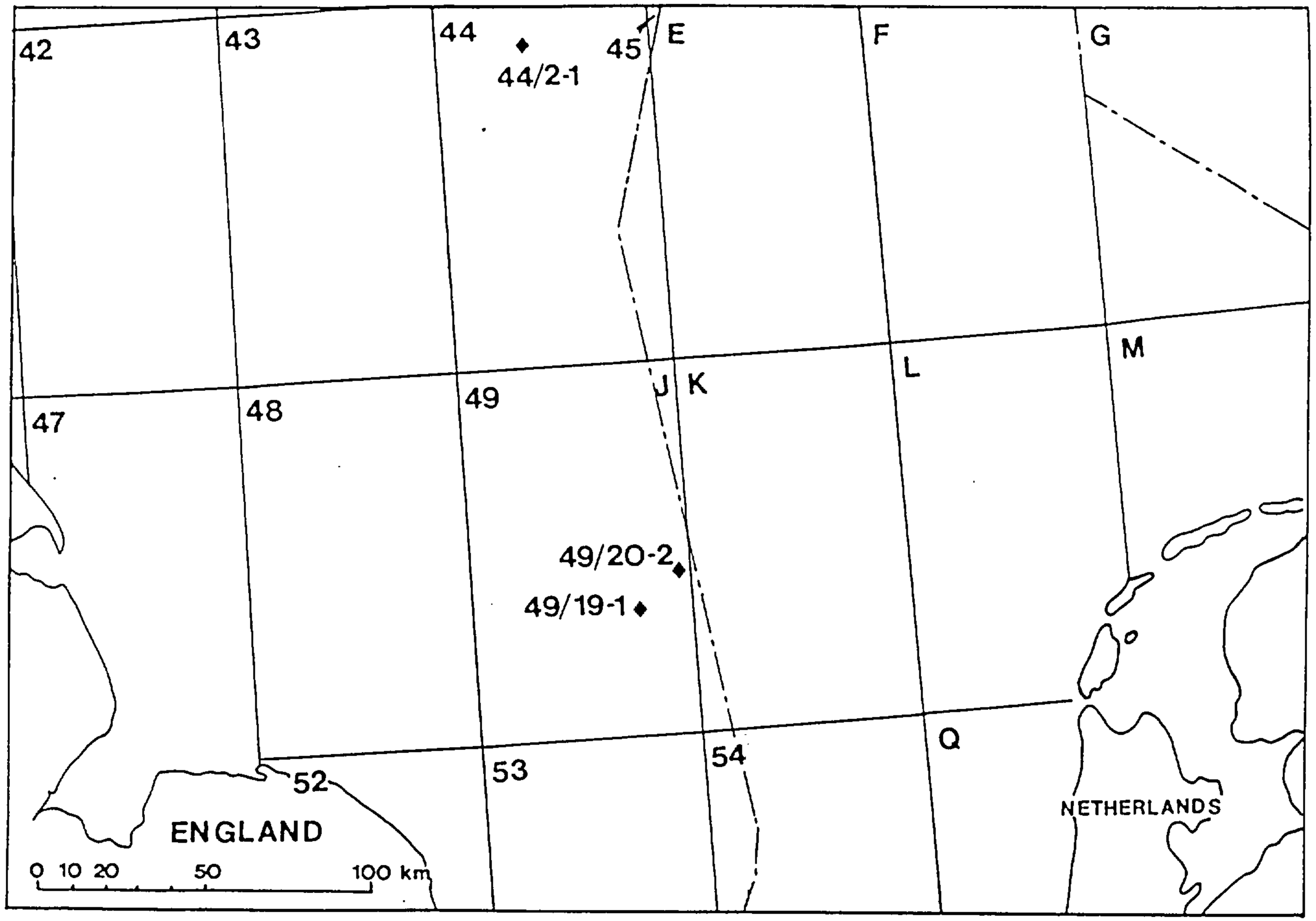

Fig. 5.5 Location of the studied boreholes in the Southern North Sea Basin

SHELL 44/2-1

The borehole was located at 54°52'38"N 02°23'35"E on the southern edge of the Mid-North Sea High. Approximately 2,130 ft. of chalk were examined which included several horizons of abundant flints (indicated on Fig.5.6). The lithologies of the samples are summarised as follows:

2,910 ft - 2,940 ft : brown, reddish-brown mudstone
2,940 ft - 3,000 ft : brown, reddish-brown mudstone with chips of white chalk
3,000 ft - 4,880 ft : white, grey-white chalk, friable to moderately hard with flints
4,880 ft - 5,040 ft : pink - brownish pink chalk

Only a Gamma Ray Log was available for the chalk of this borehole which shows a distinct decrease in gamma-ray radiation at 2,980 ft, 4,910 ft and 5,040 ft.

The lithostratigraphy is interpreted as follows:-

2,980 ft - top of the Chalk Group
4,910 ft - Plenus Marl equivalent
5,040 ft - base of the Chalk Group

If the Dutch scheme is applied to this borehole, the top of the Texel Chalk Formation/base of the Ommelanden Chalk Formation is at 4,910 ft (see Fig. 5.6).

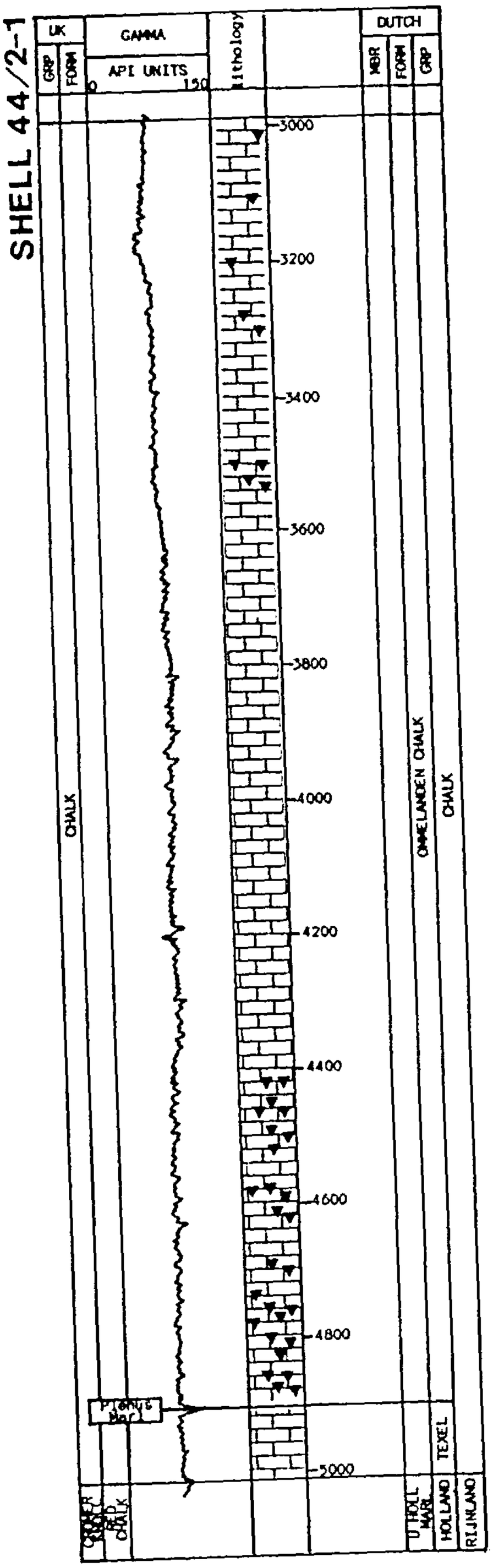

Fig. 5.6 Lithostatigraphic interpretation of Shell 44/2-1

SHELL 49/19-1

The borehole was located at 50°23'48"N, 02°45'21"E. Approximately 1,440 ft of chalk were examined and flints were particularly abundant in the upper half of the borehole (to a depth of 2,050 ft) (indicated on Fig. 5.7). The lithologies of the samples are summarised as follows:-

1,380 ft - 1,470 ft : brown, reddish-brown mudstone
1,470 ft - 1,500 ft : brown, reddish-brown mudstone with chips of white chalk
1,500 ft - 2,910 ft : white, grey-white chalk, friable to moderately hard with flints
2,910 ft - 3,020 ft : pink, pinkish-brown chalk

Only the Gamma Ray Log was available for the entire chalk sequence; the Formation Density Log was available for the interval between 2,870 ft and 3,020 ft. A distinct decrease in gamma-ray radiation is seen at 1,460 ft, 2,865 ft and 3,020 ft. A distinct increase in true bulk density is seen at 2,865 ft and 3,020 ft.

The lithostratigraphy is interpreted as follows:-

1,460 ft - top of the Chalk Group
2,865 ft - Plenus Marl equivalent
3,020 ft - base of the Chalk Group

If the Dutch scheme is applied to this borehole, the top of the Texel Chalk Formation/base of the Ommelanden Chalk Formation is at 2,865 ft (see Fig.5.7).

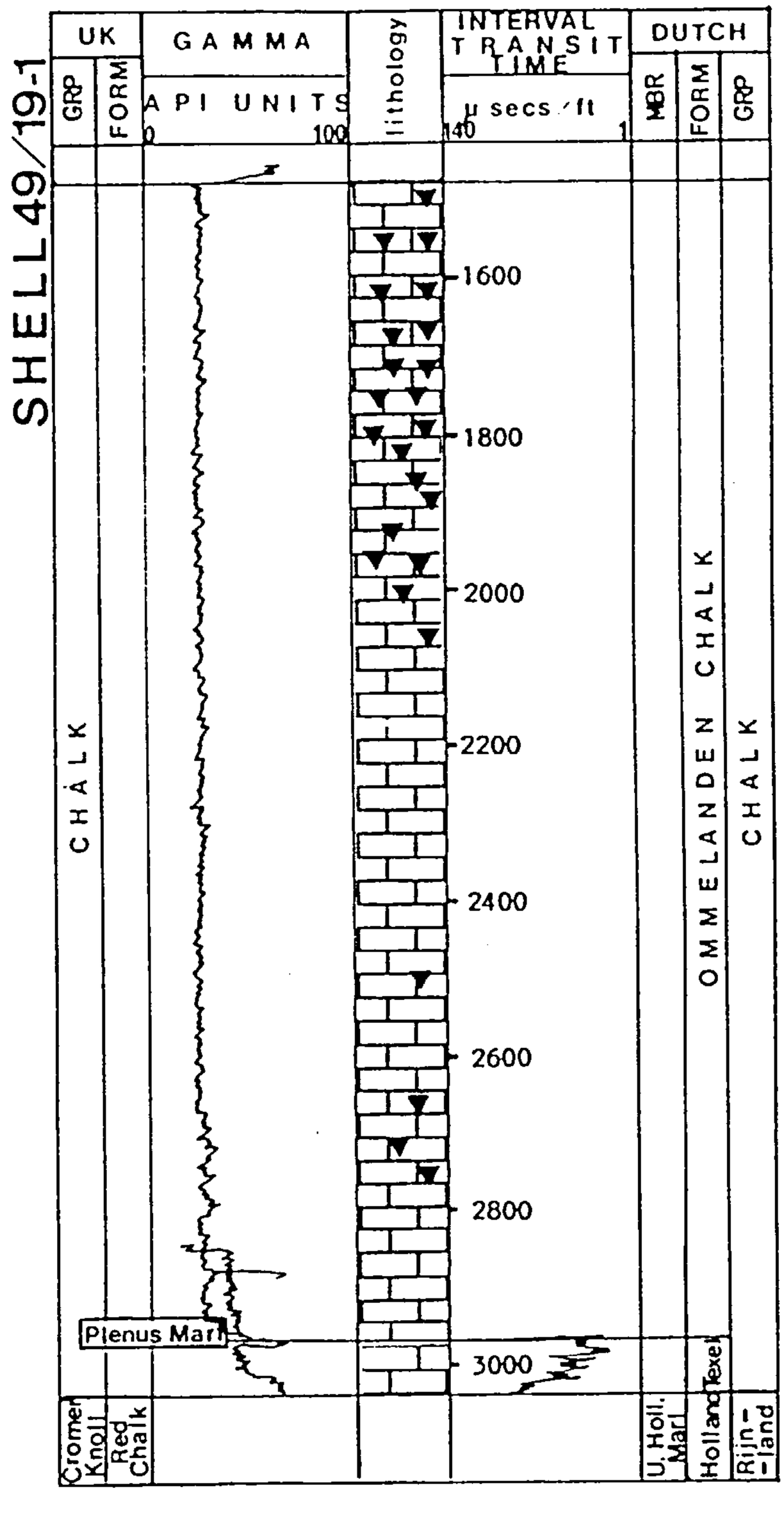

Fig. 5.7 Lithostatigraphic interpretation of Shell 49/19-1

SHELL 49/20-2

The borehole was located at 53°27'26.056"N, 02°58'15.124"E. Approximately 3,800 ft of chalk were examined; there were several horizons of abundant flints (indicated on Fig.5.8). The lithologies of the samples are summarised as follows:-

2,750 ft - 2,780 ft : red, reddish-brown mudstone
2,780 ft - 6,500 ft : white, grey-white chalk, friable to moderately hard with flints
6,500 ft - 6,610 ft : pink, brownish pink chalk

Both the Gamma Ray Log and the Formation Density Log were available for this borehole. A distinct decrease in gamma-ray radiation in association with a distinct increase in true bulk density is seen at 2,780 ft, 6,505 ft and 6,610 ft.

The lithostratigraphy is interpreted as follows:

2,780 ft - top of the Chalk Group
6,505 ft - Plenus Marl equivalent
6,610 ft - base of the Chalk Group

If the Dutch scheme is applied to this borehole, the top of the Texel Chalk Formation/base of the Ommelanden Chalk Formation is at 6,505 ft (see Fig.5.8).

The British and Dutch lithostratigraphic schemes for the Upper Cretaceous strata of the Southern North Sea Basin are thus both applicable to the boreholes in the present study. However, it is not possible to make detailed correlation and comparisons by using these

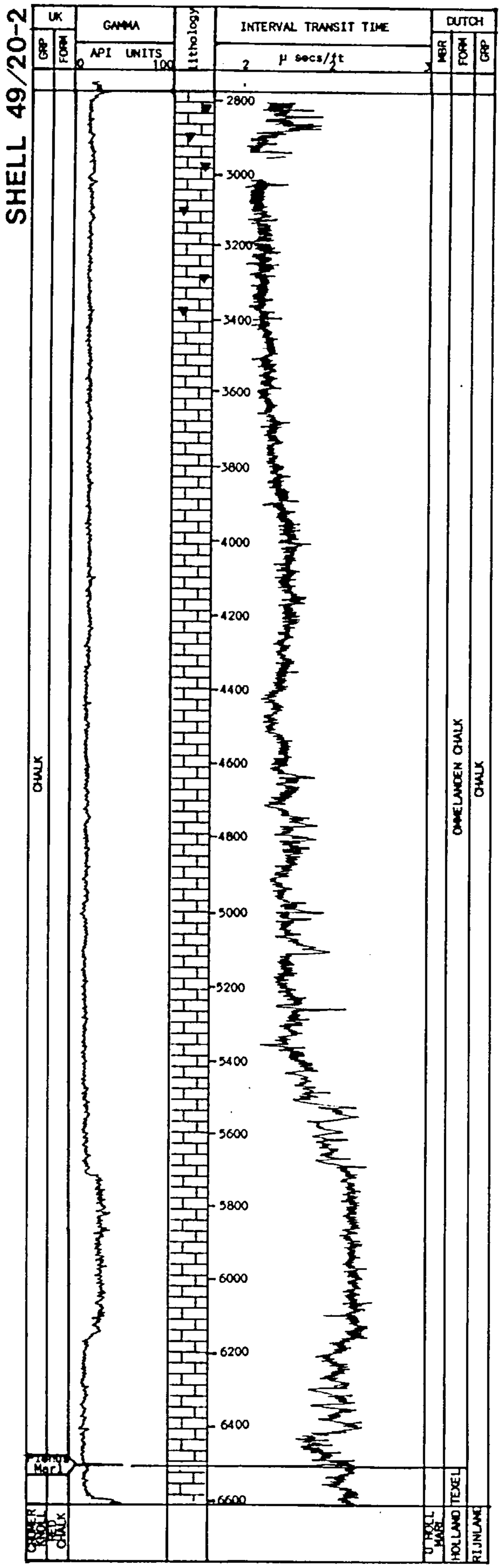

Fig. 5.8 Lithostratigraphic interpretation of Shell 49/20-2

lithostratigraphic schemes above and, at present, more detailed subdivisions of the Chalk Group must rely on the micropaleontological results.

CHAPTER 6

SYSTEMATIC DESCRIPTIONS

A detailed discussion of the classification of the Foraminifera, including analysis of the majority of previous classifications, is presented in the Treatise of Invertebrate Palaeontology, Part C, Protista, Loeblich & Tappan 1964, and subsequently amended by the same authors in 1974. Their classification has been generally accepted by all micropalaeontologists and has been followed here.

Species used in the present study were selected on the basis of stratigraphic range, abundance and ease of identification. For each species the first reference is given followed by any additional references that offer useful information on stratigraphy or taxonomic change; a complete synonymy and/or reference list is not attempted. Following a condensed description of each species are remarks on evolutionary relationships, problems of taxonomy and synonymy, an indication of average size, and occurrence throughout the studied sections. Each species has been photographed and the figured specimen assigned a specimen number.

Order FORAMINIFERIDA Eichwald 1830

Suborder TEXTULARIINA Delage & Herouard 1896

Superfamily AMMODISCACEA Reuss 1862

Family AMMODISCIDAE Reuss 1862

Subfamily AMMODISCINAE Reuss 1862

Genus AMMODISCUS Reuss 1862

Type species Ammodiscus infimus Bornemann 1874

Ammodiscus cretaceus (Reuss 1845)

(Pl.1, fig.1.)

1845 Operculina cretacea Reuss, p.35, pl.13, figs. 64, 65.
1860 Cornuspira " (Reuss); Reuss, p.177, pl.1, fig.1.
1929 " involvens (Reuss); Berry & Kelley, p.15, pl.1, fig.15.
1932 " cretacea (Reuss); Sandige, p.271, pl.41, fig.22.
1934(b) Ammodiscus " (Reuss); Cushman, p.45.
1946 " cretaceus (Reuss); Schijfsma, pp.26-28, pl.6, fig.1.
1957 " cretaceous (Reuss); McGugan, p.336, pl.34, fig.9.
1962 " cretaceus (Reuss); Tappan, p.130, pl.30, figs.1,2.
1966(b) " cretaceus (Reuss); Barr, p.495, pl.77, fig.2.
1972 " " (Reuss); Hanzlikova, p.34, pl.3, figs.1,9.
1982 " " (Reuss); Miller, Gradstein & Berggren, p.19, pl.1, fig.6.

Description: test free; discoidal; round to elliptical; spherical proloculus followed by an undivided, planispirally coiled, tubular second chamber; nine or less whorls; slightly involute; biconvex in axial view; aperture terminal; simple, single opening at end of tubular chamber; wall finely agglutinated; surface smooth to finely rugose.

Remarks: This species was originally described by Reuss from the Plåner Marl, Bohemia (1845). The illustrations of the holotype are very small, but clearly show pronounced transverse growth constrictions. Specimens with slight transverse constrictions were seen in the present study but none showed the degree of constriction exhibited by the holotype as illustrated by Reuss.

This species was originally thought to be calcareous by Reuss, but was placed in the genus Ammodiscus by Cushman (1934) after examination of type material.

Size : Diameter : 0.58mm
Width : 0.07mm

Distribution: This species first appears downhole in the Late Maastrichtian (Zone F.I.1) of the studied wells, and is rarely recorded throughout all the sections.

Superfamily LITUOLACEA de Blainville 1825
Family ATAXOPHRAGMIIDAE Schwager 1877
Subfamily VERNEUILININAE Cushman 1911
Genus VERNEUILINA d'Orbigny 1839
Type species Verneuilina tricarinata d'Orbigny 1840

Verneuilina muensteri Reuss 1854
(pl.1, fig.2.)

1845 Textularia triquetra (non Munstr.) sensu Reuss, p.39, pl.13, fig.77.
1854 Verneuilina münsteri (Reuss); Reuss, p.71, pl.26, fig.5.
1936 " limbata Cushman, p.2, pl.1, fig.2.
1937 " " Cushman, Cushman, p.12, pl.1, fig.21.
1956 Gaudryina " Said & Kenawy, p.123, pl.1, fig.23.
1957 Verneuilina " Cushman; McGugan, p.337, pl.34, figs.4-7.
1961 " münsteri (Reuss); Vasilenko, p.15, pl.1, fig.8.

1975 ____"____ (Reuss); Robaszynski in Colbeaux et al. p.19, fig.2.

1980 ____" muensteri (Reuss); Gawor-Biedowa, p.15, pl.2, figs.8,9.

1981 ____"____ (Reuss); Hart et al. in Jenkins & Murray, p.178, pl.7.3, figs. 7,8.

Description: test free and elongate, broadly wedge-shaped with sharply defined edges; triangular in cross section; increasing rapidly and uniformly in size; sides flat to slightly concave; chambers arranged triserially, distinct, with six to eight on each face; sutures flush to slightly raised and curved; apertural face inclined with small, loop or slit-shaped aperture situated towards the centre of the inner margin of the apertural face.

Remarks: this species was originally described by Reuss in 1854 from the Turonian Plänermergel, Luschitz.

In 1839, d'Orbigny erected the genera-Verneuilina and Gaudryina-differentiated by a wholly triserial test and a triserial becoming biserial arrangement respectively. Loeblich & Tappan (1964) noted the occasional occurrence of specimens of Verneuilina with a biserial test, but recorded these forms as being abnormal. The two genera are therefore regarded as completely separate and non-intergradational.

The form described as V. limbata by Cushman (1936) shares several specific characters with the original figures of V. münsteri (Reuss). However, the trivial name of V. limbata had already been used by Terquem in 1892 for an Eocene form from the Paris Basin thus making V. limbata Cushman a junior homonym and therefore invalid.

The form illustrated and described as Gaudryina limbata Said & Kenaway 1956 is considered to fall within the variation of V. muensteri.

Size: Height : 1.13mm
Width : 0.55mm

Distribution: this species 'tops' within the Early Maastrichtian (Zone F.I.2), in well Shell 49/20-2 and within the Late Campanian (Zone F.I.3) in wells Shell 44/2-1 and 49/19-1, and is recorded rarely throughout the sections.

Verneuilina sp.A.

(Pl.1, fig.3.)

1978 Verneuilina sp. A. Bailey (unpubl.), p.68, pl.1, fig.8.

Description: test free and elongate, broadly wedge-shaped with rounded edges, becoming almost lobate in later chambers; sides initially flat, but becoming slightly concave in later chambers,

chambers arranged triserially, distinct, sutures slightly curved and depressed; aperture a simple semi-circular hole in the inner margin of the apertural face; wall coarsely arenaceous.

Remarks: this species was referred to Verneuilina sp.A. by Bailey (1978 (unpubl.)). It is very similar to V. muensteri (Reuss) but can be distinguished by the more rugose appearance of the wall and by the depressed sutures.

Size : Height : 0.54mm
Width : 0.38mm

Distribution: this species 'tops' within the Late Santonian (Zone F.I.6) of wells Shell 44/2-1 and 49/19-1, and within the Late Turonian (Zone F.I.9) in 49/20-2, and is recorded only rarely in the recovered faunas.

Genus GAUDRYINA d'Orbigny 1839

Type species Gaudryina rugosa d'Orbigny 1840

Gaudryina laevigata Franke 1914

(Pl.1, Fig.,4.)

1914	Gaudryina laevigata		Franke, p.431, pl.27, figs.1, 2.
1936	"	"	Franke; Brotzen, pp.34, 35.
1956	"	"	Franke; Said & Kenawy, p.123, pl.1, fig.8.
1964	"	"	Franke; McGugan, p.940, pl.150, figs.6-8.
1972	"	"	Franke; Hanzlikova, p.52, pl.11, fig.2.

1980 " " Franke; Gawor-Biedowa, p.16, pl.1, fig.11.

Description: test free, initially rapidly flaring with flattened to slightly concave sides, becoming almost parallel-sided to gradually tapering; chambers initially indistinct and triserial, becoming distinct, inflated, subglobular and biserial; sutures indistinct, flush, becoming distinct and depressed; aperture a broad, low slit opening towards the inner margin of the final chamber; wall finely agglutinated, surface smooth.

Remarks: this species was originally described by Franke in 1914 from the Upper Cretaceous of Emscher - no type locality was designated.

This species is closely related to Gaudryina frankei Brotzen 1936. The type illustrations of the two species show broadly wedge-shaped tests with a distinct triserial portion and a distinct biserial portion. The type figures of G. laevigata indicate a greater development of the biserial portion of the test than that shown for G. frankei; the edges of the triserial part in G. frankei are more rounded than in G. laevigata where they are quite sharply acute. The inflated, almost globular, biserial chambers of G. laevigata are also characteristic. However, the original descriptions do not follow the illustrated differences and, in fact, describe the opposite. This has led to confusion in the literature and has resulted in forms referred to G. laevigata lacking subglobular, biserial chambers and hence more like G. frankei (e.g. Cushman 1946; Sliter 1968).

Size: Height : 0.9mm
Width : 0.5mm

Distribution: this species 'tops' within the Late Maastrichtian (Zone F.I.1) in well Shell 49/20-2, within the Late Campanian (Zone F.I.3) in 49/19-1, and within the Late Santonian (Zone F.I.6) in 44/2-1. It is found only rarely in the studied sections.

Gaudryina rugosa d'Orbigny 1840
(Pl.1, fig.5.)

1840 Gaudryina rugosa d'Orbigny; p.44, pl.4, figs.20, 21.
1899 " pupoides d'Orbigny; Egger, p.37, pl.4, figs.14, 15.
1917 " rugosa d'Orbigny; Chapman, p.21, pl.2, fig.21.
1937 " " d'Orbigny; Cushman, p.36, pl.4, figs.14-19, pl.5, figs.1, 2.
1953 " " d'Orbigny; Barnard & Banner, p.184, pl.9, fig.3, t.figs. 5t,U.
1957 " " d'Orbigny; Hofker, pp.63-64, t.figs.59, 60.
1966 " cretacea (Karrer); Hofker, p.20, pl.5, fig.14, pl.8, fig.15, pl.12, fig.12.
1977 " rugosa d'Orbigny; Villian, p.41, pl.3, fig.8.
1980 " " d'Orbigny; Gawor-Biedowa, pp.16-17, pl.1, figs.7, 8.

Description: test free, initially triserial and flat sided, moderately and uniformly increasing in size, becoming lobate and more rapidly flaring, eventually biserial and gradually tapering; chambers distinct, subrectangular and initially uninflated, becoming inflated;

sutures distinct, initially flush, becoming depressed; curved and slightly oblique; aperture a simple, semi-circular loop at the interior margin of the last chamber; wall coarsely agglutinated, surface rugose.

Remarks: this species was originally described by d'Orbigny in 1840, from the Upper Campanian of the Paris Basin (type locality not designated). The illustration of the holotype is small but clearly shows the biserial portion of the test forming about half of the entire length. However, Swiecicki (1980 unpubl.) noted a considerable variation in the development of this biserial portion (from 10%-60%), and when the biserial part of the test is poorly developed it may be confused with species of the genus Vernueilina. The use of chamber arrangement as a specific character is therefore considered inadvisable as this is variable and may lead to mis-identification.

G. rugosa can be distinguished from the broad wedge-shaped species G. frankei Brotzen and G. laevigata Franke by the elongated, slender test and the oval to round cross section.

Size: Height : 1.4mm
Width : 0.9mm

Distribution: this species 'tops' within the Late Maastrichtian (Zone F.I.1) of well 49/20-2, and within the Late Campanian (Zone F.I.3) of 49/19-1. It is found only rarely in these two sections, and is absent from 44/2-1.

Genus TRITAXIA Reuss 1860

Type species Textularia tricarinata Reuss 1844

Tritaxia tricarinata (Reuss 1844)

(Pl.1, fig.6a, b)

1844	Textularia tricarinata	Reuss, p.215.
1845	" "	Reuss, pt. 1, p.39, pl.8, fig.60a-b.
1851	Verneuilina dubia	Reuss, p.40, pl.4 (5), fig.3.
1860	Tritaxia tricarinata	(Reuss); Reuss, p.228, pl.12, figs. 1,2.
1892	" pyramidata	(Reuss); Chapman, p.2, pl.11, fig.2.
1928	" tricarinata	(Reuss); Franke, p.137, pl.12, fig.17.
1937	" "	(Reuss); Cushman, p.25, pl.3, figs.16-25.
1937	" dubia	(Reuss); Cushman, p.26, pl.4, figs.1-4.
1953	" tricarinata	(Reuss); Barnard & Banner, p.193, pl.8, fig.1a-e, t. fig.3a-j.
1957	" dubia	(Reuss); Hofker, p.67, t.fig.68.
1964	" tricarinata	(Reuss); Loeblich & Tappan, p.C272, fig.182, (5,6).
1966	" "	(Reuss); Butt, p.171, pl.1, fig.1.
1972	" "	(Reuss); Hanzlikova, p.54, pl.11, fig.11.

Description: test free, elongate and broadly oval in shape but highly variable - from subtriangular and rapidly flaring with concave to flat sides, to elongate, almost parallel sided; chambers indistinct and arranged triserially except in a small number which become uniserial in the adult stages; sutures indistinct, flush to slightly depressed and curved; aperture a simple opening, central and terminal

in larger elongate forms but towards the inner edge of the final chamber in smaller, shorter forms; wall finely agglutinated, surface smooth.

Remarks: this species was first described by Reuss in 1844 from the lower Plänerkalk, Kosstitz on the Ohre River, northwestern Bohemia, but was not illustrated until 1845 (Reuss). The figures are very small but clearly show a concave-sided form, broadly oval in profile with a triangular cross-section and very acute margins.

Forms referred to this species in the literature show a wide variation in basic morphology. This variation has been well illustrated by Barnard & Banner (1953) by the use of acid stripped specimens.

Bailey (1978 unpubl.) noted that shorter wider forms seem to be characteristic of the late Cenomanian to the lower Santonian, whereas the elongate forms seem to be characteristic of the late Turonian to the Santonian. This relationship is impossible to verify in the present study because of the problems with "caving".

Size: Height : 0.52mm
Width : 0.39mm

Distribution: this species was found rarely, and 'tops' within the Late Maastrichtian (Zone F.I.1) in well 44/2-1 and within the Early Campanian (Zone F.I.5) in well 49/19-1. It was not recorded from 49/20-2.

Subfamily GLOBOTEXTULARIINAE Cushman 1927

Genus ARENOBULIMINA Cushman 1927

Type species Bulimina preslii Reuss 1846

Arenobulimina advena (Cushman 1936)

(Pl.1, fig.7)

1936	Hagenowella advena	Cushman, p.43, pl.6, fig.21 a,b.
?1937	Arenobulimina anglica	Cushman; Cushman, pl.4, fig.33.
p1961	" chapmani	(Cushman); Vasilenko, pp.22-23, pl.3, fig.3 a,b, (non pl.4, figs. 2a,b,w,3).
1962	" advena	Cushman; Jefferies, pl.78, fig.13.
1969	Arenobulimina "	(Cushman); Gawor-Biedowa, pp.86-90, pl.8, figs.1-4, t. figs.7,8.
1977	" "	(Cushman); Carter & Hart, p.14, pl.2, fig.4.
1981	" "	(Cushman); Hart et al. in Jenkins & Murray, pp.174-175, pl.7.1, fig.5.
1982	" "	(Cushman); Gawor-Biedowa, pl.3, fig.1.

Description: test free, initially acute increasing rapidly and uniformly in size; chambers arranged trochospirally in three-four whorls; chambers elongate, slightly inflated, four per whorl with the last three chambers making up over half of the test; sutures distinct, depressed; apertural face convex with a distinct depresssion about the aperture; aperture an interiomarginal loop; wall coarsely arenaceous; surface smooth.

Remarks: this species was originally described by Cushman (1936) supposedly from the Upper Senonian of Junz, Pommerania, Germany. As this species has never been recorded from the Upper Senonian of northwest Europe, Brotzen (1945) has suggested that Cushman's identification of the locality was erroneous and suggests that the actual locality must have been Zunz, Pommerania, Germany where the beds are Upper Cenomanian in age, thus making this the type horizon. This view is also held by Carter & Hart (1977) and Price (1977).

The species is characterized by a complex pattern of internal marginal partitions developed in the later chambers which appear as dark and light bands on the external surface when the surface is moistened. The species is thought to have evolved from A. chapmani Cushman 1936 at or near the Albian-Cenomanian boundary (Carter & Hart 1977; Price 1977), and the two are very similar externally. Individuals with internal divisions were assigned to the genus Hagenowina by Loeblich & Tappan (1964); this is not followed by Gawor-Biedowa (1969) or Carter & Hart (1977), who find no justification in doing so. Harris (1980 unpubl.) regarded the presence of internal partitions as definitive for this species and specimens without internal partitions he designated as 'end members' of the A. chapmani plexus.

As all specimens encountered in the present study had internal partitions they are referred to A. advena.

Size: Length : 0.39mm
Width : 0.31mm

Distribution: this species is recorded from Late-Middle Cenomanian strata (Zone F.I.11) of wells 49/19-1 and 49/20-2, and from the Middle- Early Cenomanian of well 44/2-1.

Arenobulimina anglica Cushman 1936
(Pl.1, figs. 8, 9)

1936 Arenobulimina anglica Cushman, p.27, pl.4, fig.8a-b.
p.1937 " " Cushman; Cushman, p.37, pl.4, figs.31, ?32 (non figs 33,34)
1947 " " Cushman; Grekoff, p.2, pl.1, fig.5a-b.
1977 " " Cushman; Carter & Hart, p.14, pl.2, fig.3.
1981 " " Cushman; Hart et al. in Jenkins & Murray, p.174, pl.7.1, fig.6.

Description: test free, initially broadly rounded; chambers arranged trochospirally with the last whorl occupying over half of the test; chambers rounded, slightly inflated with the last chamber distinctly rounded and almost terminal; sutures distinct, depressed; apertural face with a distinct depression about the aperture; aperture an interiomarginal loop; wall finely agglutinated and 'sugary' in appearance, surface smooth.

Remarks: this species was originally described by Cushman from the Chalk Marl detritus of Charing, Kent (1936). It can be distinguished by the characteristic 'sugary' appearance of the test. The type figure shows no indication of divisions internally, but Carter & Hart (1977) record specimens from higher levels of the Chalk Marl (upper Middle Cenomanian) with slight folding of the margins of later chambers.

The specimens illustrated as this species by Cushman (1937) include a form (fig.33) with well developed internal subdivisions which could possibly be more correctly included in Arenobulimina advena (Cushman 1936).

Size: Height : 0.79mm
Width : 0.54mm

Distribution: this species is rarely recorded from material from well 49/20-2 of Middle- Early Cenomanian age (Zone F.I.12).

Arenobulimina courta (Marie 1941)

(Pl.2, fig.1)

?1851 Bulimina obesa Reuss, p.40, pl.4, fig.12, pl.5, fig.1.
1925 " " Reuss; Franke, p.26, pl.2, fig.24.
1928 " " Reuss; Franke, p.161, pl.14, fig.25.
pl937 Arenobulimina obesa (Reuss); Cushman, pp.43-44, pl.4, fig.27 only.
1941 Hagenowella courta Marie, p.43, pl.7, fig.68.
1953 " " Marie, Barnard & Banner, p.202, t.fig.6j-0.

1953 Arenobulimina obesa (Reuss); Hagn, p.20, pl.2, fig.10.

p1957 Ataxophragmium ovoideum (Marie); Hofker, pp.46-47, t.fig.35, (non t.fig.34).

p1977 Orbignyna variablis (d'Orbigny); Villain, p.42, pl.3, figs. 12-13, (non pl.3, fig.9).

Description: test free, globular; chambers arranged trochospirally in three to four whorls; chambers inflated to very inflated in the last whorl which makes up over half of the test; commonly four semi-circular chambers in the final whorl; sutures distinct, depressed; aperture a single slit or semi-circular opening mid way along the internal margin of the last chamber at the junction of the four sutures of the final whorl; wall thick, surface rugose.

Remarks: the exact relationship between this species first described by Marie in 1941, and Bulimina obesa Reuss 1851 is not clear. B. obesa was originally described from the Upper Cretaceous of Lemberg, Poland and figured in spiral and umbilical views only; these clearly show the four inflated chambers of the last whorl dominanting the test. A. courta was originally described from the Campanian (mucronata Zone) of the Paris Basin and illustrated in both spiral and side views (Marie 1941). The figures are very stylized and show the overall dominance of the last whorl in the test and the shape and inflation of the chambers in the final whorl. In his original description of 1941, Marie distinguishes A. courta from B. obesa by the broader than high test and by the oval shaped chambers; Reuss's illustrations of his holotype for B. obesa clearly show the chambers to be semi-circular. As these morphological features are variable, ideally a study of type material

is needed to determine the relationship of these two species. However, as no depository for Reuss's holotype is given this is not possible and the relationship of these two species remains unclear.

After studying topotype material of B. obesa, Cushman (1937) figured forms that he referred to as Arenobulimina obesa (Reuss). However, his concept of the species is wide and his illustrations include forms assignable to more than one species.

The species illustrated as Orbignyna variabilis (d'Orbigny 1840) by Villain includes forms that can be assigned to A. courta (pl.3, figs.12-13).

Sweicicki (1980 unpubl.) follows Marie's original description of A. courta and it is that concept that is followed here.

This species reaches a maximum size in the Late Campanian-Early Maastrichtian in the wells studied from block 49.

Size:	Height : 0.63mm	Bigger forms:	Height : 1.3mm
	Width : 0.49mm		Width : 1.0mm

Distribution: this species 'tops' within the Early Maastrichtian (Zone F.I.2) of well 49/20-2 and in the Late Campanian (Zone F.I.3) of wells 44/2-1 and 49/19-1. It is recorded rarely to commonly throughout the studied sections.

Arenobulimina elevata (d'Orbigny 1840)

(Pl.2, fig.2.)

1840 Globigerina elevata d'Orbigny, p.34, pl.3, figs.15, 16.

?1891 Haplophragmium inflatum Beissel, p.19, pl.4, figs.41-45.

1925 " subspherica Reuss; Franke, p.27, pl.2, fig.25.

1941 Hagenowella elevata (d'Orbigny); Marie, p.42, pl.7, figs.66a-b, 67.

1941 " subspherica (Reuss); Marie, p.42, pl.7, fig.66c-f.

1953 " elevata (d'Orbigny); Barnard & Banner; p.202, pl.8, figs.11a-d.

1953 Arenobulimina subspherica (Reuss); Hagn, p.22, pl.2, fig.11.

1957 Ataxophragmium " (Marie); McGugan, p.333 (list), pl.33, figs.11-12.

Description: test free, initially blunt increasing rapidly and uniformly in size; periphery lobate; chambers arranged in a high trochospire in four to five whorls; chambers semi-circular inflated and globular forming an oblique spire; commonly four chambers in the final whorl which makes up to half of the test; sutures distinct, curved and depressed; aperture a single slit or broad loop-shaped opening at the junction of the four sutures of the final whorl extending up the apertural face of the final chamber; wall thick, surface rugose.

Remarks: this species was originally described by d'Orbigny (1840) from the Campanian of the Paris Basin (type locality not designated). The original figures clearly show a high trochospire and the overall dominance of the last whorl.

A. elevata closely resembles the species Beissel referred to as Haplophragmium inflatum (1891) which he describes from the mucronata Zone and figures from Friedrichberg, Germany. The exact relationship between these two species is not clear but it seems likely that H. inflatum falls within the variability of A. elevata.

A. elevata is very similar to A. courta (Marie 1941) but may be distinguished by the larger size and high trochospire. There is no gradation apparent between the two species.

Sweicicki (1980 unpubl.) follows d'Orbigny's original description of A. elevata and it is that concept that is followed here.

This species reaches a notably maximum size in the Late Campanian-Early Maastrichtian in the borehole material from block 49.

Size: Height : 1.3mm
Width : 1.1mm

Bigger forms: Height : 2.0mm
Width : 1.7mm

Distribution: this species 'tops' within the Early Maastrichtian (Zone F.I.2) of well 49/20-2, and in the Late Campanian (Zone F.I.3) of wells 44/2-1 and 49/19-1. It is found rarely to commonly throughout the studied sections.

Arenobulimina footei Jennings 1936

(Pl.2, fig.3.)

1910 Bulimina ovata d'Orbigny; Heron-Allen & Earland, p.408, pl.6, fig.8.

1936 Arenobulimina footei Jennings, pp.13-14, pl.1, fig.9.

1941 " gutta Marie, p.51, pl.4, fig.38a-e.

1941 " ovoidea Marie, p.51, pl.4, fig.39a-d.

1947 " footei Jennings; Cushman, p.11, pl.1, fig.21.

1951 " ovoidea Marie; Visser, p.218, pl.8, fig.2.

1977 " footei Jennings; Villain, p.41, pl.4, fig.1.

Description: test free, almost parallel sided, initially blunt; chambers arranged trochospirally in four to five whorls increasing uniformly; chambers elongate, slightly inflated, three per whorl initially, increasing to four; sutures distinct, depressed and curved; aperture a single slit or broad loop-shaped opening; surface smooth to moderately rugose; surface may consist of randomly arranged grooves possibly the result of the dissolution of monaxon sponge spicules that once formed the test wall.

Remarks: this species was originally described by Jennings from the Cretaceous of Ocean County, New Jersey, U.S.A.

In 1941, Marie described two new species from the mucronata Zone of the Campanian of the Paris Basin that he referred to as A. gutta and A. ovoidea. His figures are both small and stylized but clearly resemble A. footei. The two species were differentiated in the descriptions

only by the shape of the last chamber. As this is a variable character of A. footei, A. gutta and A. ovoidea are considered to fall within the variation of A. footei.

After studying specimens in the British Museum designated by Heron-Allen & Earland as Bulimina ovata d'Orbigny 1846, Sweicicki (1980 unpubl.) concluded that they were conspecific with A. footei.

Size: Height : 0.63mm
Width : 0.29mm

Distribution: this species first appears downhole in the Late Maastrichtian (Zone F.I.1) in all the studied sections and occurs rarely to commonly in the recorded faunas.

Arenobulimina obliqua (d'Orbigny 1840)

(Pl.2, fig.4)

1840 Bulimina obliqua d'Orbigny, p.40, pl.4, figs.7, 8.
1931(b) Arenobulimina obliqua (d'Orbigny); Cushman, p.36, pl.5, fig.5.
1934 " " (d'Orbigny); Cushman & Parker, p.28, pl.5, figs.5, 6.
1935 " preslii (Reuss); Keller, p.544, pl.1, figs.5,6.
1937 " obliqua (d'Orbigny); Cushman, p.41, pl.4, figs.18-20.
1937 Bulimina " d'Orbigny; Marie, p.261.
1941 Arenobulimina " (d'Orbigny); Marie, pp.47-48, pl.4, fig.34 a-f.

1941 " conica Marie, pp.48-49, pl.4, fig.35a-d.

1941 " sphaerica Marie, p.49, pl.4, fig.36a-e.

1941 " cytherea Marie, p.52, pl.4, fig.40a-c.

1947 " obliqua (d'Orbigny); Grekoff, pp.496-497, pl.2, fig.10.

1947 " sphaerica Marie; Grekoff, p.499, pl.2, fig.13.

1947 " cytherea Marie; Grekoff, p.493-494, pl.2, fig.5.

1953 " obliqua (d'Orbigny); Hagn, p.20, pl.2, fig.5.

1953 " cytherea Marie; Hagn, p.20, pl.2, fig.9.

1972 " obliqua (d'Orbigny); Hanzlikova, p.56, pl.12, fig.16.

1977 " " (d'Orbigny); Villain, p.41, pl.4, fig.4.

Description: test free, conically shaped, initially acute, increasing rapidly and uniformly in size; chambers arranged trochospirally in three to four whorls, chambers elongate, slightly inflated and markedly oblique; four to six per whorl with the last chamber becoming large, inflated and strongly overlapping the previous whorl; sutures distinct, flush to slightly depressed, curved; apertural face flat with a broad loop-shaped aperture opening at the interior margin of the last chamber; wall finely agglutinated, surface smooth or occasionally becoming rugose.

Remarks: this species was originally described and figured by d'Orbigny in 1840 from the Campanian of the Paris Basin. His figures are very stylized but clearly show the diagnostic, initially acute,

sharply conical form and the last chamber flat and characteristically overlapping. The lack of essential features shown by d'Orbigny has possibly resulted in the great variation within this species.

In 1934, Cushman & Parker figured material from the Craie Blanche of Bougival, France, which is referred to as being "practically topotype material". The specimen has a larger apical angle that of the type figures but was noted by Bailey (1978 unpubl.) as being typical of the specimens found in the Coniacian-Santonian of southern England.

In 1941, Marie described and figured three species also from the Campanian of the Paris Basin. The illustrations of the three species - Arenobulimina conica, A. cytherea and A. sphaerica are highly stylized but clearly resemble the type figures of A. obliqua. The three species are shown to differ only in the degree of tapering of the test-from the most rapidly flaring form - A. sphaerica to the most gradually flaring from - A. cytherea. As this is a varying character of A. obliqua, A. conica, A. cytherea and A. sphaerica are considered to fall within the variation of A. obliqua.

Size: Height : 0.67mm
Width : 0.55mm

Distribution: this species 'tops' within the Late Maastrichtian (Zone F.I.1) and is recorded rarely to commonly throughout all the studied sections.

Arenobulimina puschi (Reuss 1851)

(Pl.2, fig.5.)

1851 Bulimina puschi Reuss, pp.37-38, pl.4, fig.6a-b.
1860 " " Reuss; Reuss, p.226.
1934 Arenobulimina puschi (Reuss); Cushman & Parker, p.30, pl.5, fig.18a-b.
1953 Arenobulimina puschi (Reuss); Hagn, p.22, pl.2, fig.8.
p.1957 Ataxophragmium puschi (Reuss); Hofker, pp.44-45, t.fig.31, nos. a,b,f,k, (non c,d,e,g-j).

Description: test free, initially broadly rounded increasing gradually to the greatest width at or slightly above mid-point of the test; periphery slightly lobate; chambers arranged trochospirally in five to six whorls; chambers subglobular, inflated, three chambers per whorl with the last chamber slightly overlapping the previous whorl; sutures distinct, depressed and curved; aperture an interiomarginal loop extending up the apertural face; wall coarsely agglutinated, surface rugose.

Remarks: this species was originally described by Reuss (1851) from the Upper Cretaceous of Lemberg, Poland. The figures of the holotype clearly show the characteristic triserial test and coarse agglutination.

Size: Height : 0.46mm
Width : 0.35mm

Distribution: this species has its highest occurrence in the Late Maastrichtian (Zone F.I.1) in Shell 49/20-2, in the Early Maastrichtian (Zone F.I.2) in 44/2-1, and in the Late Campanian (Zone F.I.3) in 49/19-1, and is recorded rarely in the studied sections.

Genus DOROTHIA Plummer 1931

Type species Gaudryina bulletta Carsey 1926

Dorothia pupa (Reuss 1860)

(Pl.2, fig.6a, b)

1860 Textularia pupa Reuss, p.232, pl.13, figs.4,5.
1870 Gaudryina crassa Karrer, p.166, pl.1, fig.4.
?1899 Textularia pupa Reuss; Egger, p.26, pl.2, fig.29.
1925 Gaudryina pupoides d'Orbigny; Franke, p.14, pl.1, fig.26.
1925 Textularia conulus f. pupa Reuss; Franke, p.11, pl.1, fig.12.
1928 " " f. " Reuss; Franke, p.132, pl.12, fig.5.
1928 Gaudryina pupoides d'Orbigny; Franke, p.143, pl.13, fig.7.
1936 Dorothia plummeri Brotzen, p.36, pl.1, figs.6, 8, t-fig.6.
1937 " pupa (Reuss); Cushman, p.78, pl.8, figs.22,24.
1937 Gaudryina pupoides d'Orbigny; Marie, p.261.
1953 Dorothia pupa (Reuss); Hagn, pp.25-26, pl.2, figs.19-22.
1953 " " (Reuss); Barnard & Banner, p.191, pl.8, fig.3, t-figs. 2i, 4b,e.

1953 " " (Reuss); var. depressa Barnard & Banner, p.191, pl.8, figs.4a, b, t-fig.4c.

1953 " " (Reuss); var. tenuis Barnard & Banner, p.192, pl.8, fig.5, t-fig.4h.

1957 " " (Reuss); Hofker, p.37, t-fig.21.

1964 " " (Reuss); McGugan, p.941, pl.150, figs.15, 16.

1968 " " (Reuss); Sliter, p.50, pl.4, fig.1.

1972 " " (Reuss); Hanzlikova, p.57, pl.12, fig.8, pl.13, figs.3, 8.

1972 " bulletta (Carsey); Hanzlikova, p.57, pl.12, figs.4,9.

1977 " pupa (Reuss); Villain, p.43, pl.3, fig.6.

Description: test free and conical, initially trochospiral, becoming biserial, gradually and uniformly expanding; cross-section initially circular, becoming ovoid; initial whorl has four to six, rapidly expanding chambers, followed by six to ten, biserially arranged gradually expanding chambers; chambers slightly inflated and overlapping; sutures initially obscure but distinct and horizonal in the biserial part of the test and slightly depressed throughout; aperture varies from an elongate, crescentric slit to an arched slit along the inner margin of the final chamber; wall finely agglutinated with much calcareous cement, surface smooth.

Remarks: this species was originally described from the Senonian of Westphalia, Germany (1860). It is very similar to Dorothia bulletta (Carsey) described from the Upper Cretaceous of Texas. In Reuss's original figures of D. pupa, the sutures are shown to be very

depressed, whereas those of D. bulletta are less so. After examining topotype material of D. bulletta deposited in the British Museum, Sweicicki (1980 (unpubl)) concluded that the two are separate species.

Size: Height : 0.68mm
Width : 0.47mm

Distribution: this species was recorded very rarely from the Late Maastrichtian (Zone F.I.1) of Shell 44/2-1 and the Late Campanian (Zone F.I.3) of 49/19-1.

Genus MARSSONELLA Cushman 1933

Type species Textularia trochus d'Orbigny 1840

Marssonella trochus (d'Orbigny 1840)

(Pl.2, fig.7a,b.)

1840 Textularia trochus d'Orbigny, p.45, pl.4, figs.25,26.

1840 " turris d'Orbigny, p.46, pl.4, figs.27,28.

1860 Gaudryina oxycona Reuss, p.229, pl.12, fig.3.

1899 Textularia trochus d'Orbigny; Egger, p.28, pl.14, figs.27,28.

1899 " turris d'Orbigny; Egger, p.29, pl.14, fig.29.

1928 " trochus d'Orbigny f. typica, Franke, p.130, pl.12, fig.2.

1928 " turris d'Orbigny; Franke, p.131, pl.12, fig.3.

1929 " oxycona Reuss; Cushman & Church, p.501, pl.36, figs.3,4.

1933b Marssonella oxycona (Reuss); Cushman, p.36, pl.4, fig.13.

1951 " " (Reuss); Bandy, p.492, pl.72, fig.8.

1953 " trochus (d'Orbigny); Barnard & Banner, p.204, t.fig.5 o-s.

1956 " oxycona (Reuss); Said & Kenawy, p.127, pl.1, fig.48.

1957 " " (Reuss); McGugan, pp.337-338, pl.33, fig.8.

1963 " trochus (d'Orbigny); Barnard, pp.42-43, t.fig.3a-q.

?1963 " turris (d'Orbigny); Barnard, pp.42-43, t.fig.2a-h.

1964 Dorothia oxycona (Reuss); Loeblich & Tappan, p.C275, fig.184, (5a-c).

1966 Marssonella " (Reuss); Hofker, p.35, pl.4, fig.8; pl.8, fig.16; pl.15, fig.6; pl.18, fig.23; pl.20, fig.20; pl.22, fig.70.

1972 Dorothia trochus (d'Orbigny); Gawor-Biedowa, pp.30-31, pl.2, fig.4.

1972 " turris (d'Orbigny); Gawor-Biedowa, pp.32-33, pl.2, figs.5,6.

1972 " oxycona (Reuss); Hanzlikova, p.57, pl.11, figs.8,10.

1973 Marssonella trochus (d'Orbigny); Koch, p.210, pl.18, figs.4,5.

1980 Dorothia " (Reuss); Gawor-Biedowa, pp.19-20, pl.2, fig.3.

Description: test free and broadly conical with circular to oval cross-section, varying from initially accute to broadly rounded; chambers arranged trochospirally with four to five per whorl but decreasing regularly and rapidly in number until biserial; biserial portion varying from rapidly flaring to gradually tapering and almost parallel-sided; chambers initially indistinct but later distinct; uninflated and broader than high; the last two chambers flattened to slightly inflated; sutures distinct, flush to slightly depressed and straight; aperture a simple interiomarginal broad slit in slight re-entrant in the final chamber, wall finely agglutinated, surface slightly rugose.

Remarks: two very similar species - Marssonella trochus and Marssonella turris were described by d'Orbigny from the Campanian of the Paris Basin (1840). The type figures show the two species to be

almost identical but varying in the degree of flaring of the test; M. trochus was illustrated as a rapidly flaring form whilst M. turris a gradually tapering form. The degree of tapering is a highly variable feature and the two forms illustrated by d'Orbigny are probably the end members of a plexus of one highly variable species.

In 1860, Reuss described a form from Germany (type level and locality not designated) which he referred to as Gaudryina oxycona. The type figures clearly show the species to have very similar characteristics to the forms described by d'Orbigny in 1840 - a slightly rugose surface, a trochospiral portion rapidly becoming biserial and the final two chambers slightly inflated with a low, broad slit aperture re-entrant in the final chamber. The test is illustrated as moderately flaring and it would seem likely that M. oxycona is an intermediate form between M. turris and M. trochus and a member of the same highly variable plexus.

Some of the samples in the present study yielded all three forms and a complete gradation has been seen in the character of flaring - from gradual to moderate to rapidly flaring forms thus strengthening the idea that these forms belong to one, highly variable species. The most commonly found form was the 'oxycona' form with 'turris' and 'trochus' being encountered rather rarely. Swiecicki (1980 unpub.) referred these three species and intermediates to one species under the name M. trochus as this was the first specific name used. This concept is followed in the present study.

It is unlikely that the form illustrated by Barnard (1963) as M. turris from Cenomanian to Santonian localities can be referable to this species as this was originally described from the Campanian, and these are stratigraphical older forms.

Size: Height : 0.70mm
Width : 0.48mm ('oxycona form')

Distribution: this species has its highest occurrence in the Late Maastrichtian (Zone F.I.1) in wells Shell 44/2-1 and 49/20-2, and in the Late Campanian in 49/19-1 (Zone F.I.3). It is recorded rarely to very commonly throughout the sections.

Genus EGGERELLINA Marie 1941
Type species Bulimina brevis d'Orbigny 1840

Eggerellina brevis (d'Orbigny 1840)
(Pl.3, figs.1a,b, 2a,b)

1840 Bulimina brevis d'Orbigny, p.41, pl.4, figs.13,14.
1925 " murchisoniana d'Orbigny; Franke, p.27, pl.2, fig.22.
non 1925 " brevis d'Orbigny; Franke, p.25, pl.2, fig.18.
1928 " trilobata Franke, p.161, pl.14, fig.26.
non 1928 " brevis d'Orbigny; Franke, p.157, pl.15, fig.12.
1941 Eggerellina " (d'Orbigny) var. conica. Marie, p.34, pl.7, fig.70.
1941 " intermedia (Reuss); var. globulosa Marie, p.33, pl.7, fig.69.

1941 " gibbosa Marie, var. globulosa Marie, p.35, pl.7, fig.71.

1941 " " Marie, var. conica Marie, p.35, pl.7, fig.73.

1941 " ventricosa Marie, p.36, pl.7, fig.72.

1941 " ovoidea Marie, p.36, pl.7, fig.74.

1947 " intermedia (Reuss), var. globulosa Marie; Cushman, pp.18-19, pl.3, fig.15.

1947 " brevis (d'Orbigny), var. conica Marie; Cushman, p.19, pl.3, fig.15.

1947 " gibbosa Marie, var. conica Marie; Cushman, p.19, pl.4, fig.1.

1947 " gibbosa Marie, var. globulosa Marie; Cushman, p.20, pl.4, fig.2.

1947 " ventricosa Marie; Cushman, p.20, pl.4, fig.3.

1947 " ovoidea Marie; Cushman, p.20, pl.4, fig.4.

1953 " gibbosa Marie, var. globulosa Marie; Barnard & Banner, p.203, pl.8, fig.12.

1953 " " Marie, var. conica Marie; Barnard & Banner, p.203, pl.8, fig.13.

1964 " brevis (d'Orbigny), var. conica Marie; Loeblich & Tappan, p.C277, fig.186, (6a,b.).

1964 " intermedia (Reuss), var. globulosa Marie; Subbotina, p.207, pl.33, fig.8, pl.34, fig.12.

Description: the alternation of generations during the life history of foraminifera may produce two distinct forms - a microspheric form (usually produced during the schizont generation) and a megalospheric

form (usually representing the gamont generation). The present species displays well-documented dimorphism and the two dimorphs are described separately:

(i) Microspheric form: test free, initially bluntly pointed to broadly rounded, flaring rapidly to give a conical outline; chambers arranged trochospirally in three to four whorls; chambers inflated and subglobular, three per whorl, with the last whorl distinctly overlapping and making up over half of the test, usually only two to two and a half chambers in the final whorl; cross-section usually trilobed, occasionally bilobed; sutures obscure until the last whorl where they are distinct and depressed; aperture a 'key-hole' shaped opening at right angles to the inner margin of the final chamber, extending up the apertural face and surrounded by a slight apertural lip; wall finely to moderately coarsely agglutinated with calcareous particles, surface smooth to slightly rugose.

(ii) Megalospheric form: test free, subglobular with a distinct trilobed appearance and lobate periphery; chambers arranged trochospirally in two, occasionally three whorls; initial whorls extremely small but the last whorl extremely large and distinctly overlapping with three inflated chambers and distinct, depressed and slightly curved sutures; cross-section trilobed; aperture a 'key-hole' shaped opening extending up the apertural face but varying in position according to the rate of the trochospiral coiling-often central at the junction of the sutures in the final whorl; wall finely to moderately coarsely agglutinated with calcareous particles, surface smooth to slightly rugose.

Remarks: this species was originally described by d'Orbigny in 1840 from the Campanian of the Paris Basin. The type figures clearly show the dominance of the last overlapping whorl, the trilobed appearance and the 'key-hole' shaped aperture. In spite of this clarity, this species has had a somewhat confused history due to the variability in the rate of coiling, (which governs the number of chambers visible from the summit), the position of the aperture and the distinct dimorphism.

Marie (1941) erected a suite of species and varieties based on these variable features, all of which fall within the range of variation of E. brevis. This figures are highly stylized but the forms E. ovoidea, E. ventricosa and E. gibbosa var. globulosa are clearly assignable to the microspheric dimorph of E. brevis, and E. gibbosa var. conica, E. brevis (d'Orbigny) var. conica and E. intermedia (Reuss) var. globulosa can be referred to the megalospheric dimorph.

As a result of Marie's work (1941), British members of this highly variable plexus of E. brevis have usually been referred to E. gibbosa var. globosa Marie and E. gibbosa var. conica Marie (e.g. Barnard & Banner 1953; Bailey 1978 unpubl.). Marie considered the distinctive features of this species and its two varieties to be the asymmetrical test and only two chambers visible from the summit. Swiecicki (1980 unpubl.) recorded extremely rare forms of this arrangement from the British Campanian and noted the more usual arrangement to be two and a half chambers visible from the summit. He concluded that these forms cannot strictly be referred to E. gibbosa and its varieties, and the specific characters fall within the range of specific variability of E. brevis. This concept is followed here.

Cushman (1948) regarded d'Orbigny's species Bulimina brevis as having a perforate calcareous wall and as a true Bulimina. This is rejected by Marie (1941) and Loeblich & Tappan (1964); the wall is agglutinated but composed of calcareous particles and thus Eggerellina brevis is an agglutinated form, and not a buliminid.

The wide range of morphological variation exhibited by this species resulting in a confused taxonomic history requires revision and the exact relationship of the closely similar forms of E. intermedia (Reuss 1851) and E. (?) murchisoniana (d'Orbigny 1840) needs clarification.

This species reaches a maximum size in the Late Campanian-Early Maastrichtian in the wells from block 49 (Ball, in press).

Size: Megalospheric form:

Height 0.56mm		Bigger forms : Height	1.17mm
Width 0.49mm		Width	0.96mm
Microspheric form:			
Height 0.42mm		Bigger forms : Height	0.83mm
Width 0.40mm		Width	0.79mm

Distribution: this species 'tops' within the Late Maastrichtian (Zone F.I.1) of wells 44/2-1 and 49/20-2, and within the Early Maastrichtian (Zone F.I.2) of 49/19-1, and is recorded rarely to commonly throughout the studied sections.

Eggerellina mariae ten Dam 1950

(Pl.3, fig.3)

1950 Eggerellina mariae ten Dam, pp.15-16, pl.1, fig.17.
1962 " sp. Jefferies, pl.79, fig.5.
1972 " mariae ten Dam; Gawor-Biedowa, pp.33-34. pl.3, figs.1a-b, 2a-b.
1977 " " ten Dam; Carter & Hart, p.17. pl.2, fig.7.
1981 " " ten Dam; Hart et al. in Jenkins & Murray, pp.176-177, pl.7.2, figs.1,2.
1982 " " ten Dam; Gawor-Biedowa, pl.4, figs.7,8.

Description: test free and varying in form from short and conical, to elongate and narrow with a conical to ovoid longitudinal profile; chambers distinct, globose and inflated and arranged trochospirally in three to four whorls; sutures distinct, depressed and curved; aperture a narrow, elongated interiomarginal slit extending to half way up the apertural face; wall finely agglutinated, surface smooth.

Remarks: this species was first described by ten Dam (1950) from the Albian of boreholes in the eastern part of the Netherlands, (type locality not designated). The type figures show a highly variable external form - from conical (ten Dam 1950, pl.1, fig.17a-c) to ovoid (ten Dam 1950, pl.1, fig.17,d-e). The wide variation shown by this species has subsequently been noted by Carter & Hart 1977 and Hart et al. 1981.

Carter & Hart (1977) record the presence of a variety of forms of Eggerellina from individual samples from certain levels within the Cenomanian-particularly the lower horizons of the Plenus Marl. These variants were regarded as intergradational and members of one plexus beginning with the ancesteral E. mariae in the Albian and ending with Eggerellina brevis (d'Orbigny 1840) at higher levels within the Cretaceous. This possible evolutionary relationship between these two species is difficult to comment on in the present study because of the rareity with which E. mariae is encountered and the problems with 'caving' from higher levels.

Size: Height : 0.3mm
Width : 0.19mm

Distribution: this species appears 'downhole' within the Late-Middle Cenomanian (Zone F.I.11) of wells 44/2-1 and 49/20-2, and is recorded only rarely in the microfaunas.

Genus PLECTINA Marsson 1878

Type species Graudryina rutherica Reuss 1851

Plectina cenomana Carter & Hart 1977

(Pl.3, fig.4.)

1962 Verneuilina polystropha (Reuss); Jefferies, pl.78, fig.14.

1977 Plectina cenomana Carter & Hart; pp.12-13, pl.2, fig.9.

1981 " " Carter & Hart; Hart et al. in Jenkins & Murray, pl.176, pl.7.2, fig.10.

Description: test free, initially acute and rapidly tapering, chambers arranged trochospirally in two to three whorls, initially up to five chambers per whorl, becoming triserial and may be ending with a final pair of chambers, giving an overall triserial appearance; sutures distinct and depressed; apertural face with a distinct depression about the aperture; aperture a simple, rounded or occasionally oval opening in the final chamber; wall moderately coarsely agglutinated, surface smooth to slightly rugose.

Remarks: this species was originally described by Carter & Hart from the Upper Cenomanian of Buckland Newton, Dorset(1977). It can be differentrated from other members of the genus by the overall triserial appearance. The nature of the early growth stages and apertural characteristics are clearly similar to those of P. mariae (Franke 1928) but the exact relationship is unclear.

Size: Height : 0.48mm
Width : 0.34mm

Distribution: this species appears within the Late-Middle Cenomanian (Zone F.I.11) of all the studied wells, where it is recorded only rarely in the microfaunas.

Plectina mariae (Franke 1928)

1928 Gaudryina ruthenica Reuss; var. mariae Franke, p.146, pl.13, fig.15a-b.

1937 Plectina " (Reuss); var. mariae (Franke); Cushman, p.106, pl.11, fig.15.

1948 " " (Reuss); Williams-Mitchell, p.97, pl.8, fig.3.

1962 " " (Reuss); Jefferies, pl.78, fig.12.

1972 " " mariae (Franke); Gawor-Biedowa, p.34, pl.3, fig.3a-b.

1982 " " " (Franke); Gawor-Biedowa, pl.2, fig.8.

Description: test free, initially acute and gradually flaring; chambers arranged trochospirally, initially up to five chambers per whorl, rapidly becoming biserial; chambers broadly rounded giving a lobate outline, three to four pairs in the biserial portion; sutures distinct and depressed; aperture a simple interiomarginal opening; wall fine grained, surface smooth to slightly rugose.

Remarks: the number of chambers in the biserial growth stage is variable. This is a distinctive species although the initial growth stages and apertural characteristics are very similar to those of Plectina cenomana Carter & Hart 1977, thus making it possible to confuse the juvenille form of the two species.

Size: Height : 0.6mm
Width : 0.2mm

Distribution: this species was only rarely recorded from the Middle- Early Cenomanian (Zone F.I.12) of well Shell 49/20-2.

Subfamily ATAXOPHRAGMIINAE Schwager 1877

Genus ATAXOPHRAGMIUM Reuss 1860

Type species Bulimina variabilis d'Orbigny 1840

Ataxophragmium sp.A. sp.nov.

(Pl.3, fig.6a,b)

1941 Ataxogyroidina globulosa (von Hagenow); Marie, p.59, pl.5, figs.50-57.

pl966 Ataxophragmium globulosum (von Hagenow); Hofker, p.33, pl.4, fig.9, (non pl.4, fig.10).

1977 " " (von Hagenow); Villain, p.43, pl.4, figs.2, 3.

Description: test free, asymmetrical, sometimes subspherical, tending to planoconvexity; chambers arranged trochospirally in two to three (generally two) overlapping evolute whorls; chambers indistinct and slightly inflated, higher than broad; six chambers per whorl with the last chamber tending to overlap the previous whorl; sutures distinct and flush; apertural face flattened; aperture a single, sub-rectangular, deep slit, extending along the interiomarginal suture of the last chamber; wall thick, surface smooth.

Remarks: in 1842, von Hagenow described a form from the Chalk of Rügen, Germany, which he called Nonionina globulosa. The holotype was never figured and no depository is given.

In 1941, Marie, following the description given by von Hagenow, described and figured this distinct species of Ataxophragmium from the 'mucronata' Zone of the Campanian of the Paris Basin, and referred it to N. globosa von Hagenow, noting the characteristic form, the agglutinating test and apertural characteristics. However, many (e.g. Reuss 1861; Marsson 1878; Cushman 1931; Visser 1951) have concluded that the species originally described by von Hagenow is a calcareous, perforate form and assignable to the genus Gyroidinoides. The species described by Marie (1941) is similar in shape to that described for N. globosa but is clearly agglutinated. Therefore, the two cannot be considered conspecific.

In 1946, Schijfsma described and figured the species Ataxogyroidina pseudoglobosa from the mid-Campanian of a borehole northwest of Heerlen, southern Limburg in the Netherlands. The figures clearly show a coarsely agglutinated form with a flattened apertural face bearing a loop-shaped aperture. Schijfsma includes in his synonomy of this species, forms referred by Marie to Ataxogyroidina globosa but the figures of A. pseudoglobosa do not show the characteristic form, the subrectangular aperture and the smooth surface of Marie's species. Therefore, the two cannot be regarded as conspecific.

Sweicicki (1980 unpubl.) figured a form with a coarsely agglutinated test and a deep sub-rectangular aperture which he referred to a new species of Ataxophragmium. This is the same species that is here referred to as Ataxophragmium sp. A.

This species reaches a maximum size in the Late Campanian-Early Maastrichtian of the wells from block 49 (Ball, in press).

Size: Height : 0.72mm Bigger forms : Height : 0.94mm
Width : 0.64mm Width : 0.86mm

Distribution: this species is recorded from the Late Maastrichtian downwards (Zone F.I.1) in well 49/20-2 and from the Early Maastrichtian downwards (Zone F.I.2) in wells 49/19-1 and 44/2-1. It is recorded rarely to moderately frequently.

Ataxophragmium rimosum (Marsson 1878)

(Pl.4, fig.1a, b)

1878 Bulimina rimosa Marsson, p.153, pl.3, fig.21.
1934 Ataxophragmium rimosum (Marsson); Cushman & Parker, p.32, pl.6, figs.3-5.
1965 Orbignyna " (Marsson); Pozaryska, p.59, pl.1, fig.3.
p1966 " " (Marsson); Hofker, p.87.
1977 Ataxophragmium " (Marsson); Jørgensen, p.313, pl.1, figs.10,12.

Description: test free, subspherical; chambers arranged in a tightly coiled helical spire of two to three distinctly over-lapping whorls; chambers obscured by the strong ornamentation of randomly arranged grooves; chambers generally wider than high with last chamber inflated and overlapping onto the previous whorl; sutures flush;

aperture variable from a simple, semi-circular interiomarginal opening on the final chamber, to a narrow slit extending up the apertural face; surface roughened by randomly arranged grooves.

Remarks: this species was originally described by Marsson (1878) from the Chalk of Rügen Island, Germany. The type figures show clearly the species to have a narrow slit aperture extending up the apertural face and the test surface marked by randomly arranged, longitudinal grooves. It is a less variable form than Ataxophragmium variable (d'Orbigny 1840) and can be distinguished from other members of the genus by the distinctive surface sculpturing.

Longitudinal grooves are known from both fossil and recent tests and maybe the result of the dissolution of sponge spicules that were once cemented together to form the test (Loeblich & Tappan 1964; Jørgensen 1977).

Hofker (1956a) recognised this type of agglutination as a specific character and suggested that A. rimosum was one form of a single species that exhibited trimorphism characterised by this distinctive agglutinating habit. In his one species, Hofker included forms belonging to the genera Ataxophragmium, Plectina and Orbignyna, including Orbignyna ovata von Hagenow 1842. As the stratigraphical ranges recorded for A. rimosum and O. ovata are different they are unlikely to be different forms of the same species, and are, therefore, not regarded as conspecific.

This species reaches a maximum size in the Late Campanian-Early Maastrichtian in the wells from block 49.

Size: Height : 0.53mm Biggger forms: Height : 0.62mm
Width : 0.49mm Width : 0.62mm

Distribution: this species has its highest occurrence towards the base of the Late Maastrichtian (Zone F.I.1) in all the studied wells section. It is recorded rarely to moderately frequently.

Ataxophragmium variabile (d'Orbigny 1840)
(Pl.4, fig.2a,b)

pl840 Bulimina variabilis d'Orbigny, p.40, pl.4, figs.9,10,?11 (non 12)
1891 Polyphragma variabile (d'Orbigny); Beissel, p.20, pl.4, figs.46-53.
1897 Bulimina variabilis d'Orbigny; Perner, pp.26-27, pl.13, fig.2.
1931b Ataxophragmium variabilis (d'Orbigny); Cushman, p.38, pl.5, fig.6.
1934 " variabile (d'Orbigny); Cushman, p.28, pl.5, figs.2-4.
1936 " compactum Brotzen, pp.44-46, t.fig.8, pl.2, figs.3, 10.
1941 Ataxogyroidina variabilis (d'Orbigny); Marie, p.56, pl.4, figs.41, 42, pl.5, figs.43, 44, 47.
1941 " cylindrica Marie, p.57, pl.5, fig.46.
1941 " ovoidea Marie, p.57, pl.5, fig.40.
1941 " concava Marie, p.58, pl.5, fig.45.
1941 " gibbosa Marie, p.58, pl.5, fig.49.

1947 " cylindrica Marie; Cushman, p.61, pl.6, fig.3.

1947 " ovoidea Marie; Cushman, p.62, pl.3, fig.9.

1947 " concava Marie; Cushman, p.62, pl.6, fig.2.

1947 " gibbosa Marie; Cushman, p.62, pl.6, fig.4.

1951 Ataxophragmium variabile (d'Orbigny); Noth, p.39, pl.5, fig.5.

1953 " variabilis (d'Orbigny); Barnard & Banner, pp.205-206, pl.9, fig.6, t.fig.7.

1953 " compactum Brotzen; Hagn, p.29, pl.2, fig.14.

1957 Orbignyna sp. McGugan, pl.35, fig.33.

1961 Ataxophragmium compactum Brotzen; Vasilenko, p.26, pl.4, figs.4,6.

1964 " variabile (d'Orbigny); Loeblich & Tappan, pp.C283-C284, fig.191 (1,2).

1977 " compactum Brotzen; Jørgensen, p.313, pl.1, figs.4,5.

1980 " variabile (d'Orbigny); Gawor-Biedowa, p.21, pl.2, figs. 16,17.

Description: test free, subglobular to elongate with a variable outline, but broader than high; chambers arranged in a helical spire of two to three loosely to tightly coiled overlapping whorls; chambers increasing rapidly in size with the last chamber overlapping onto the previous whorl; sutures flush to slightly depressed; apertural face flattened; aperture usually a simple semi-circular opening at the inner margin of the last chamber but varies to a narrow elongate slit that extends up the apertural face; wall thick, surface smooth or may be slightly rugose.

Remarks: this species was originally described by d'Orbigny in 1840 from the Campanian of the Paris Basin. The species was described as highly variable - from oval-shaped and rapidly flaring to oblong-shaped and moderately flaring with a variably shaped aperture. This species is the type for the genus Ataxophragmium Reuss 1860, and d'Orbigny's originally wide concept of the species has resulted in much taxonomoic confusion.

D'Orbigny (1840) originally recorded B. variabilis as being common at Sens, rare at Meudon and St. Germain (Paris Basin) and rare in England. He figured three specimens one of which he described as being a "regular individual" (pl.4, figs.9, 10) and the other two as being "deformed" (pl.4, figs.11, 12). Marie (1941) considered the "deformed", uncoiled specimens to belong to the genus Orbignyna von Hagenow 1842 and errected a new genus -Ataxogyroidina for the more regular, tightly coiled forms, designating B. variabilis d'Orbigny 1840 as the type species. However, as B. variabilis had already been described as the type for Ataxophragmium Reuss 1860; (1893), Ataxogyroidina is a junior isogenotypic synonym of Ataxophragmium (Loeblich & Tappan 1964). (A type species for Ataxophragmium was never actually designated, but B. variabilis was cited as such by Sherborn in 1893).

The variation of B. variabilis figured by d'Orbigny has subsequently led to the subdivision of the taxon into several species (e.g. Brotzen 1936; Marie 1941). Marie (1941), described and figured four new species from the Campanian of the Paris Basin - Ataxogyroidina concava, A. cylindrica, A. gibbosa and A. ovoidea, all tightly coiled forms differing slightly in overall shape (from oblong to oval) and in

apertural characteristics. They all have very similar stratigraphic ranges and as complete gradation is seen between them and A. variabile, they are considered to be within the variation of A. variable.

Loeblich & Tappan (1964) in an attempt to clarify the taxonomic confusion, designated a lectotype for the species, based on d'Orbigny's figured specimens. The lectotype chosen was the regular form (d'Orbigny 1840, pl.4, figs, 9,10) and they too conclude that d'Orbigny's figures include forms referable to more than one genus.

Sweicicki (1980 unpubl.) follows d'Orbigny's original concept and recognises this species as being highly variable. It is this wide concept that is followed here.

This species reaches a maximum size in the Late Campanian-Early Maastrichtian in the wells from block 49 (Ball, in press).

Size: Height : 0.72mm Bigger forms: Height : 1.36mm
Width : 0.62mm Width : 1.02mm

Distribution: this species 'tops' within the Late Maastrichtian (Zone F.I.1) of all the studied wells and is recorded rarely to commonly throughout the sections.

Genus ORBIGNYNA von Hagenow 1842

Type species Orbignyna ovata von Hagenow 1842

Orbignyna ovata von Hagenow 1842

(Pl.4, fig.3a,b)

1842 Orbignyna ovata von Hagenow, p.573, pl.9, fig.26.

1861 Haplophragmium ovatum (von Hagenow); Reuss, p.328, pl.5, figs.8,9.

1878 Lituola ovata (von Hagenow); Marsson, p.171, pl.5, fig.40.

1937 Orbignyna " von Hagenow; Cushman, p.180, pl.21, figs.23-29.

1941 " " von Hagenow; var. conica Marie, p.25, pl.1, fig.10.

1953 " " von Hagenow; Barnard & Banner, p.200, pl.9, fig.7.

pl956 " " von Hagenow; Hofker, p.64, pl.5, fig.3a-b, (non fig.3c-d).

1957 " " von Hagenow; McGugan, pl.34, figs.1-3.

1964 " " von Hagenow; Loeblich & Tappan, pp.C289-C290, fig.195, (6,7)

Description: test free, elongate and compressed; initially a broadly rounded planispiral coil of five to six chambers becoming evolute with the last one or two chambers partially uncoiled; cross-section sub-circular to ellptical; chambers indistinct, uninflated and initially strongly overlapping on the inner coiled margin but later uniformly and moderately expanding; sutures initially indistinct but later distinct, depressed and curved; apertural face weakly inflated with a distinct depression about the aperture; aperture a simple terminal, circular to elliptical pit; wall coarsely

agglutinated, surface roughened by many longitudinal grooves - probably the result of dissolution of the monaxon sponge spicules that once formed part of the test.

Remarks: this species was originally described by von Hagenow in 1842 from the Chalk of Rügen, Germany. The figures of the type specimen are small but clearly show the test as initially planispiral followed by two uncoiled chambers with a simple, terminal almost circular aperture in a small depression. The type of agglutination is not indicated.

In 1941, Marie illustrated and described the form O. ovata var. conica from the Campanian of the Paris Basin. The figures are very stylized but a coarse agglutinated test and rough surface are clearly indicated.

The character of the agglutination seen in O. ovata is like that of Ataxophragmium rimosum (Marsson 1878) and led Hofker (1956a) to suggest that these two species were infact two forms of the same species - this type of agglutination being a specific character. As the stratigraphic ranges recorded for these are different, this seems unlikely.

This species reaches a maximum size in the Late Campanian - Early Maastrichtian in the wells from block 49.

Size: Height : 0.88mm Bigger forms : Height : 1.47mm
Width : 0.66mm Width : 0.91mm

Distribution: this species has its highest occurrence within the Late Maastrichtian (Zone F.I.1) of all the studied sections, and is recorded as occurring rarely to abundantly throughout the well sections.

Orbignyna sherlocki Barnard 1953
(Pl.4, fig.4a,b)

1953 Orbignyna sherlocki Barnard in Barnard & Banner, p.201, pl.9, figs.5a-b, t.fig.6a.

Description: test free, small and conical, initially a blunt and slightly curved helical spire of four to five chambers, later becoming uncoiled and subrectangular with up to six drum-shaped chambers, increasing rapidly and uniformly in size; sutures flush or slightly depressed and straight; apertural face almost circular, weakly inflated with a distinct depression about the aperture; aperture a simple, central, terminal, circular to ellptical opening; wall coarsely agglutinated, surface rugose.

Remarks: this species was originally described by Barnard in 1953 from the 'mucronata' Zone of the Campanian from Council's Pit, Norfolk. It can be distinguished from Orbignyna ovata von Hagenow 1842 by its conical form, the circular, weakly inflated apertural face and moderately rugose surface.

This species reaches a maximum size in the Late Campanian - Early Maastrichtian in the wells from block 49.

Size:	Height : 0.62mm	Bigger forms	Height : 1.02mm
	Width : 0.44mm		Width : 0.85mm

Distribution: this species is recorded rarely from the wells 49/19-1 and 49/20-2, ranging from the Late Maastrichtian downwards (Zone F.I.1). It is not recorded from well 44/2-1.

Genus VOLVOSHINOVELLA Loeblich & Tappan 1964

Type species Lituola aequisgranensis Beissel 1886

Volvoshinovella aequisgranensis (Beissel 1891)

(Pl.4, fig.5a,b)

?1840 Bulimina variabilis d'Orbigny, p.40, pl.4, fig.12, (non pl.4, figs.9-11).

?1886 Lituola aequisgranensis Beissel, p.138, no fig.

1891 " " Beissel; Beissel, p.12, pl.3, figs.1-16.

1910 Haplophragmium inflatum (Reuss); Heron-Allen & Earland, p.405, pl.6, figs.4, 8.

1928 " aequisgranensis (Beissel) f.typica Franke, p.172, pl.15, fig.22.

1937 Orbignyna " (Beissel); Cushman, p.182, pl.21, figs.31,32.

1941 " variabilis (d'Orbigny); Marie, p.26, pl.6, figs.61-65.

1951 " aequisgranensis (Beissel); Visser, p.221, pl.8, fig.5.

1953 " typica (Franke); Barnard & Banner, pp.200-201, pl.9, fig.8.

?1953 " aequisgranensis (Beissel); Barnard & Banner, pp.199-200, pl.9, fig.10.

1964 Volvoshinovella " (Beissel); Loeblich & Tappan, p.C291, fig.198, 1-6.

pl977 Orbignyna variabilis (d'Orbigny); Villain, p.42, pl.3, fig.9 only.

Description: test free, almost circular in cross-section, initially a broadly rounded planispire of about six chambers followed by two to three uncoiled, uniserial chambers very gradually increasing in size so that the test is almost parallel-sided; chambers wider than high and becoming increasingly inflated; sutures distinct, flush and oblique but later nearly horizontal; apertural face domed with a simple, deeply sunk, central, terminal, circular aperture; wall finely to moderately coarsely arenaceous, surface smooth to slightly roughened.

Remarks: this species was originally described by Beissel in 1886 from the 'mucronata' Zone of the Aachen area of Germany, (type locality not designated) but was not figured until 1891. Beissel figured a wide range of variability in overall form, but 'typically' this species has an uncoiled test and linear sutures. These two features, plus a smoother surface distinguish it from the closely related Orbignyna ovata von Hagenow 1842.

Loeblich & Tappan (1964) erected the genus Volvoshinovella with the present species designated as type. They noted the similarity between Volvoshinovella and Orbignyna - both having coiled tests initially but distinguished Volvoshinovella by the uncoiling habitat and rounded cross-section.

Rapidly flaring, conical forms have, in the past, also been assigned to this species (e.g. Beissel 1891; Franke 1928; Loeblich & Tappan 1964). Barnard and Banner (1953) gave the 'typica' form of Franke species status for the uncoiling, parallel-sided forms and referred the uncoiling, rapidly flaring, conical forms to O. aequisgranensis. O. typica (Franke) of Barnard and Banner follows Beissel's original concept of V. aequisgranensis and is thus a junior synonym. It is possible that the rapidly flaring conical forms may be a separate species but only parallel-sided forms were found in the present study and they are therefore all referred to V. aequisgranensis.

Marie (1941) noted that included in d'Orbigny's original figures of Bulimina variabilis (1840) was an Orbignyna like form which may be referable to the present species.

Swiecicki (1980 unpubl.) recorded only parallel-sided forms from Norfolk and the Isle of Wight which he referred to V. aequisgranensis

Size: Height : 1.56mm
Width : 0.96mm

Distribution: this species has its highest occurrence within the Late Maastrichtian (Zone F.I.1) of well 44/2-1, and within the Late Campanian (Zone F.I.3) of wells 49/19-1 and 49/20-2. It is recorded only very rarely in the studied sections.

Suborder ROTALINA Delage & Herouard 1896
Superfamily NODOSARIACEA Ehrenberg 1838
Family NODOSARIIDAE Ehrenberg 1838
Subfamily NODOSARIACEA Ehrenberg 1838
Genus NEOFLABELLINA Bartenstein 1948
Type species Flabellina rugosa d'Orbigny 1840

Neoflabellina baudouiniana (d'Orbigny 1840)

(Pl.5. fig.1)

1840 Flabellina baudouiniana d'Orbigny; p.24, pl.2, figs.8-11.
1910 " " d'Orbigny; Heron-Allen & Earland, p.422, pl.8, fig.4.
1925 " " d'Orbigny; Franke, pp.63, 65, pl.5, fig.15.
1954 Neoflabellina " (d'Orbigny); Pozaryska, pp.262-263, t.fig.10.
1957 Palmula " (d'Orbigny); Pozaryska, p.165, pl.27, fig.3.
1958 Neoflabellina " (d'Orbigny); Witwicka, pl.8, fig.1.

1970 ____"____"____ (d'Orbigny); Porthault in Donze et al. p.54, pl.8, fig.6.

1970 ____"____aff. baudouiniana (d'Orbigny); Porthault in Donze et al. p.54, pl.8, fig.9.

Description: test free, large, slightly compressed and palmate; initially planispirally coiled, becoming uncoiled in later stages; chambers initially arc-shaped, curved, becoming much broader than high and moderately thick; sutures distinct - raised, thickened and curved ridges; aperture terminal, at the end of a distinct short neck; wall calcareous and perforate, surface between sutures generally smooth but may have extremely sparsely distributed papillae.

Remarks: this species was originally described by d'Orbigny from the Lower Campanian of the Paris Basin (1840). It has since been recorded by Owen (1970) throughout the Turonian of southern England, and by Bailey (1978 unpubl.) from the Lower Senonian of southern England.

This species shows a wide range of morphological variation in the nature of sutural ridges, ornamentation and chamber shape.

Size: Height : 0.70mm
Width : 0.50mm

Distribution: this species 'appears' downhole within the mid-Campanian (Zone F.I.4) of wells 49/19-1 and 49/20-2, and is recorded only rarely. One specimen only was encountered within the Coniacian (Zone F.I.10) of well 44/2-1 from the ditch sample 4,580'-4,610'.

Neoflabellina deltoidea (Wedekind 1940)
(Pl.5, fig.2.)

1940 Flabellina deltoidea Wedekind, pp.186, 190, 194, figs. 3, 4, 6.
1940 " " mut. pachydisca Wedekind, pp.186-191, figs.3a-c, 4a-c.
1956 Neoflabellina " (Wedekind); Hiltermann & Koch, p.37, fig.4, nos.1-6, pl.1, 2, fig.2.
1962 " " (Wedekind); Hiltermann & Koch, p.308, pl.48, fig.12.
1970 " " (Wedekind), Porthault, in Donze et al. pp.54-55, pl.8, figs.4, 5.

Description: test free, compressed and palmate, broadly rhomboid in outline; sides flat, parallel; initially a weakly developed planispiral coil, enclosed by later chambers; chambers distinct and flat, initially sub-triangular, becoming broader than high; sutures distinct, raised in

septal ridges; aperture terminal, frequently at the end of a short apertural neck; wall calcareous and perforate, surface normally smooth with occasional development of small sparsely distributed papillae.

Remarks: the recognition of Wedekind's subspecies was not possible in the present study as this species was only encountered rarely and was frequently broken. However, Porthault (1970) states that the differences in Wedekinds sub-species are insufficient for their separation. No comment can be made on the validity of Wedekind's subspecies because of the rareity of material in the present study.

Size: Height : 0.62mm
Width : 0.39mm

Distribution: rare, broken individuals referable to this species were found at the base of the mid-Campanian (Zone F.I.4) in well 49/19-1 only.

Neoflabellina praerugosa Hiltermann 1952

(Pl.5, fig.3.)

1952 Neoflabellina praerugosa Hiltermann, p.53, fig.3, nos. 12,13.
1962 " " Hiltermann; Hiltermann & Koch, pp.307-308, pl.49, fig.12.
1966 " " Hiltermann; Salaj & Samuel, p.133, pl.27, fig.21.
1970 " " Hiltermann; Porthault in Donze et al. pp.52-53, pl.8, fig.7.

Description: test free, compressed and palmate; sides flat, parallel; initially a weakly developed planispiral coil, becoming uncoiled in later stages; chambers initially subtriangular, becoming much broader than high as the test becomes uncoiled; sutures distinct, raised into thickened ridges and separated in the centre by a remnant apertural neck; aperture terminal, at the end of a weakly developed apertural neck; wall calcareous and perforate, surface normally smooth but small nodes are rarely developed on some early chambers.

Remarks: this species may be differentiated from N. deltoidea (Wedekind) by the initial planispiral coil not being fully enclosed by the later chambers.

Bailey (1978 (unpubl.)) records this species from the Early Coniacian to the Early Campanian, (although only rarely in the latter part of its range), of southern England. N. praerugosa probably gave rise to N. rugosa (d'Orbigny) early in the Campanian.

Size: Height : 0.52mm
Width : 0.26mm

Distribution: very rare fragmented specimens of this species were found in the mid-Campanian (Zone F.I.4) of well 49/19-1. Two samples from well 44/2-1 also yielded individuals of this species - one from the Early Santonian and Zone F.I.7 (sample 4,460'-4,490'), the other from the Early Turonian and Zone F.I.10 (sample 4,730'-4,760'). The latter examples are thought to be caved.

Neoflabellina reticulata (Reuss 1851)

(Pl.5, fig.4.)

1851 Flabellina reticulata Reuss, p.30, pl.2, fig.22.

1891 " favosa Beissel, p.49, pl.19, figs.25-28, pl.26, fig.28.

1899 " reticulata Reuss; Egger, p.107, pl.13, figs.5-7.

1927 Frondicularia reticulata (Reuss); Plummer, p.39, pl.2, fig.5.

1928 Flabellina " Reuss; White, p.204, pl.28, fig.15.

1928 " " Reuss; Franke, p.93, pl.8, fig.19.

1930 " " Reuss; Cushman, p.32, pl.4, figs.18. 19.

1932 " " Reuss; Cushman & Jarvis, p.37, pl.11, fig.15.

1940b Palmula " (Reuss); Cushman, pl.20, fig.9.

1952 Neoflabellina " (Reuss); Hiltermann, t-fig.3, figs.38, 39.

1955 " " (Reuss); Hiltermann & Koch, p.371, t-fig.7f, pl.29, fig.10.

1957 " " (Reuss); Hofker, p.146, t-fig. 173.

1957 " postreticulata Hofker, p.14, t-figs.174-176.

1958 " reticulata (Reuss); Witwicka, pl.8, fig.4.

1962 " " (Reuss); Hiltermann & Koch, p.309, pl.50, figs.13, 14.

1969 Palmula reticulata (Reuss); Mello, p.64, pl.7, fig.6.

1977 Neoflabellina reticulata (Reuss); Koch, p.58, pl.14, figs.9, 10.

1977 " " (Reuss); Villain, pp.49-50, pl.4, fig.12.

1981 " " (Reuss); Hart et al. in Jenkins & Murray, p.212, pl.7.20, fig.3.

Description: test free, compressed, palmate to deltoid; sides flat, parallel; initially a weakly developed planispiral coil, rapidly uncoiling in later stages; chambers chevron shaped, strongly overlapping and increasing uniformly and moderately in size; sutures distinct, raised, slightly curved and crenulate; aperture subcircular and terminal at the end of a weakly developed apertural neck; wall calcareous and perforate, surface between sutures strongly ornamented by numerous ridges perpendicular to the sutures.

Remarks: this species was originally described from the Maastrichtian of Lemberg, Galicia (Reuss 1851). It is characterised by the regular reticulate ornament by which it may be distinguished from its ancestor Neoflabellina praereticulata, Hiltermann 1952.

Size: Height : 0.68mm
Width : 0.42mm

Distribution: rare, often broken specimens of this species have been recorded from the base of the Late Maastrichtian (Zone F.I.1) and throughout the Early Maastrichtian (Zone F.I.2) of well 44/2-1. One sample from the basal mid-Campanian (Zone F.I.4) of well 49/19-1 also yielded very rare specimens; the occurrence of these individuals at this level is thought unusual compared with published records (e.g. Hart et al. 1981), and their presence here is explained by 'caving'.

Neoflabellina rugosa (d'Orbigny 1840)

(Pl.5, fig.5)

1840 Flabellina rugosa d'Orbigny, p.23, pl.2, figs. 4,5.7.

?1858 " interpuncta von der Marck, p.53, pl.1, fig.5.

1910 " " von der Marck; Heron-Allen & Earland, p.422, pl.8, fig.5.

non 1910 " rugosa d'Orbigny; Heron-Allen & Earland, p.422, pl.8, fig.7.

1925 " interpuncta von der Marck; Franke, p.64, pl.5, fig.13.

non 1925 " rugosa d'Orbigny; Franke, p.64, pl.5, fig.12.

non 1930 " " d'Orbigny; Cushman, pp.32-33, pl.4, fig.15.

non 1931 " " d'Orbigny; Plummer, p.166, pl.12, fig.4.

1936 " " d'Orbigny; Brotzen, pp.107-108, t-fig.35.

1940 " caesata Wedekind, p.199, pl.9, figs.8-10.

1940 " sphenoidalis Wedekind, pp.196-197, pl.9, figs.16-23, pl.11, fig.5.

1941 " rugosa d'Orbigny; Marie, p.137, pl.17, figs.193-194.

?1953 Neoflabellina rugosa (d'Orbigny); Hagn, pp.57-60, pl,5, fig.12.

1954 " " (d'Orbigny); Pozaryska, p.261, fig.17.

pl1954 " " (d'Orbigny); Frizzell, p.97, pl.12, fig.16, non.fig.15.

1957 " " (d'Orbigny); Hiltermann & Koch, p.274, t.fig.1, figs.7-14.

1964 " " (d'Orbigny); McGugan, p.942, pl.150, figs.18, 19.

1964 ____"____ (d'Orbigny); Loeblich & Tappan, p.C522, fig.407-6.

1968 ____"____ (d'Orbigny); Sliter, pp.71-72, pl.8, fig.21.

1972 ____"____ ex. gr. rugosa (d'Orbigny); Hanzlikova, p.71, pl.17, fig.7.

1975 ____"____ rugosa sphenoidalis (Wedekind); Koch, p.210, pl.1, fig.7.

?1975 ____"____ caesata (Wedekind); Koch, p.210, pl.1, fig.8.

?1977 ____"____"____ (Wedekind); Koch, p.46, pl.16, fig.3.

1977 ____"____ sphenoidalis (Wedekind); Koch, p.45, pl.16, fig.2.

1977 ____"____ (d'Orbigny); Koch, p.45, pl.16, fig.4.

1981 ____"____ (d'Orbigny); Hart et al. in Jenkins & Murray, p.212, pl.7.20, fig.1.

1981 ____"____ (d'Orbigny); Gazdzicka, p.83, pl.22, fig.12.

Description: test free, compressed and palmate; sides flat, parallel; initial end broadly rounded and a weakly developed planispiral coil, rapidly uncoiling in later stages; chambers chevron shaped and narrow, increasing uniformly in size; sutures distinct, raised into thickened, slightly curved ridges and separated in the centre by a remnant apertural neck; aperture subcircular and terminal at the end of a weakly developed apertural neck; wall calcareous and perforate, surfaces between sutures ornamented by one or two rows of distinct, raised papillae.

Remarks: this species was originally described from the Campanian of the Paris Basin (d'Orbigny 1840). The elongate, palmate test and raised papillate ornament are characteristic, and many authors have recognised several subspecies (e.g. Wedekind 1940; Koch 1977; Swiecicki 1980 (unpubl.)). A lectotype was erected and figured by Loeblich and Tappan (1964) but no type locality or horizon was given.

Size: Height : 0.68mm
Width : 0.42mm

Distribution: rare individuals (often fragmentary) of this species were recorded from the Campanian (Zones F.I.3-F.I.5) of well 44/2-1. Very rare specimens were also recorded from the Late Campanian (Zone F.I.3) of well 49/19-1.

Genus VAGINULINOPSIS Silvestri 1904

Type species Vaginulina soluta Silvestri var. carinata Silvestri 1898

Vaginulinopsis scalariformis Porthault 1970

(Pl.5, fig.6.)

1970 Vaginulinopsis scalariformis Porthault in Donze et al. pp.51-52, pl.8, fig.1, 2, t-fig.3a,b.
1978 " " Porthault; Bailey (unpubl).
pp.120-121, pl.5, fig.4.
1979 " " Porthault; Bailey & Hart, p.161.
1980 " " Porthault; Robaszynski et al. p.277.
1981 " " Porthault; Hart et al. in Jenkins & Murray, p.222, pl.7.25, fig.7.

1984 " " Porthault; Ball, pp.10-12, pl.1, fig.5.

Description: test free, large and compressed; ovoid in cross-section; initially a tight planispiral coil, but rapidly becoming uniserial; chambers distinct and low; sutures distinct and subhorizontal; test surface characteristically marked by thickened, transverse septal ridges; aperture radiate and terminal on the peripheral dorsal angle of the final chamber.

Remarks: this highly distinctive species has been recorded from the Senonian of S.E.France (Porthault 1970; Robaszynski 1980), S.E. England (Bailey 1978 (unpubl); Bailey & Hart 1979; Hart et al. 1981), and recently from the southern North Sea Basin (Ball 1984).

Size: Height : 0.78mm
Width : 0.43mm

Distribution: rare, fragmentary specimens referable to this species were recorded rarely from the Early Santonian (Zone F.I.7) Of well 49/19-1.

Superfamily BULIMINACEA Jones 1875

Family TURRILINIDAE Cushman 1927

Subfamily TURRILININAE Cushman 1927

Genus PRAEBULIMINA Hofker 1953

Type species Bulimina reussi Morrow 1934

Praebulimina carseyae (Plummer 1931)

(Pl.5, fig.7a, b)

1910 Bulimina elegans d'Orbigny; Heron-Allen & Earland, p.409, pl.6, fig.11.

1926 " compressa (non Bailey, 1851) Carsey, p.29, pl.4, fig.14.

1931 Buliminella carseyae Plummer, p.179, pl.8, fig.9.

1936 " hofkeri Brotzen, p.129, pl.8, fig.3, t.fig.45.

1937 " carseyae Plummer, Loetterle, p.58, pl.5, fig.10.

?1941 Bulimina intermedia Reuss; Visser, p.257, pl.2, fig.14.

1941 Buliminella obtusa (d'Orbigny) var. inflata Marie, p.199, pl.30, fig.293, pl.31, fig.294.

1944(d) " carseyae Plummer; Cushman, p.12, pl.2, fig.24, p.93, pl.14, fig.10.

1954 " carseyae Plummer; Frizzell, pp.37-38, pl.16, figs.37, 38.

pl1957 " obtusa (d'Orbigny); McGugan, p.341, pl.32, figs.7.8, non figs.5,6.

1957 Praebulimina hofkeri (Brotzen); Hofker, pp.186-187, t.fig.225.

1957 " carseyae (Plummer); Hofker, p.192, figs.235-237.

1961 Buliminella " Plummer; Vasilenko, p.171, pl.38, figs.6, ?14

1962 Praebulimina " (Plummer); Tappan, p.186, pl.48, figs.11-15.

1964 Buliminella " Plummer; Martin, p.88, pl.11, fig.11.

1966 Praebulimina " (Plummer); Hofker, p.58, pl.10, figs.94, 95, 99, 100, pl.20, fig.38, pl.24, fig.160.

1969 " " (Plummer); Hanzlikova, p.30, pl.5, fig.5.

1972 ____"____"____ (Plummer); Hanzlikova, p.76, pl.18, figs.6, 14.

1981 ____"____"____ (Plummer); Hart et al. in Jenkins & Murray, p.214, pl.7.20, figs.15, 16.

Description: test free, ovate, initially bluntly pointed increasing gradually to the greatest width slightly below or at mid-point of the test, broadly subfusiform in outline; chambers arranged trochospirally in generally four whorls; chambers distinct, inflated and elongate, four chambers per whorl with the last chamber strongly overlapping the previous whorl; sutures distinct, depressed and curved, aperture variabile, commonly a trilateral slit and subterminal, extending along interiomarginal suture in a pronounced apertural depression; wall calcareous, surface smooth.

Remarks: the step-like outline, quadriserial chamber arrangement and the inflated chambers serve to distinguish this species from other members of the genus.

After examining forms identified by Heron-Allen & Earland as Bulimina elegans d'Orbigny 1839 in the British Museum (Nat. Hist), Swiecicki (1980 (unpubl.) concluded that they were conspecific with P. carseyae.

The earliest forms from the Early Campanian are reported to be small and slender with less inflated chambers, whilst forms from the mid and Late Campanian are more typical (Swiecicki 1980 (unpubl.); Hart

et al. 1981). Small forms were encountered in the present study but because of the problems due to caving, this distinct stratigraphic relationship was not clear.

Size: Height : 0.64mm
Width : 0.36mm

Distribution: this species appears 'downhole' towards the base of the Late Maastrichtian (Zone F.I.1) in wells 49/19-1 and 49/20-2, and at the base of the Early Maastrichtian (Zone F.I.2) in well 44/2-1. It is recorded uncommonly and sporadically throughout the studied sections.

Praebulimina laevis (Beissel 1891)
(Pl.5, fig.8a,b)

1891 Bulimina laevis Beissel, p.66, pl.12, figs.39-43.
1936 Buliminella laevis (Beissel); Cushman & Parker, p.6, pl.2, fig.3.
non 1941 Buliminella obtusa (d'Orbigny) var. laevis (Beissel); Marie, p.199, pl.30, fig.293, pl.31, fig.294.
?1941 Buliminella guttiformis Marine, p.200, pl.31, fig.295.
1947 Buliminella laevis (Beissel); Cushman & Parker, p.57, pl.15, fig.6.
1956 " " (Beissel); Said & Kenawy, p.142, pl.4, fig.6.
1957 Praebulimina " (Beissel); Hofker, p.190, t.fig.288 g, h, t.figs.230-232.

1966 ___"___ (Beissel); Hofker, p.37, ?pl.5, fig.27, pl.10, figs.70-72, 77, 78.

1981 ___"___ (Beissel); Hart et al. in Jenkins & Murray, p.214, pl.7.21, figs.1, 2.

Description: test free, subfusiform, initially bluntly pointed, increasing rapidly until the final whorl which is gradually flaring, almost parallel-sided and comprises two-thirds of the test, chambers arranged trochospirally in three to four whorls; chambers distinct, slightly inflated, four chambers per whorl; sutures flush to very slightly depressed in initial whorls; aperture variable, comma-shaped, occasionally bordered by a distinct lip, set in a distinct apertural depression, apertural face sub-terminal, wall calcareous and perforate, surface smooth.

Remarks: this species was originally described from the Maastrichtian of Germany (Beissel 1891). The original figures show a wide range of morphological variation which may have included more than one species. As a result, this species has often been confused with P. carseyae (Plummer) and P. obtusa (d'Orbigny) (e.g. Marie 1941; Brotzen 1945). Toptotype material figured by Cushman & Parker (1947) and Hofker (1966) clearly shows the species major characteristics - the weakly inflated chambers and the elongate, slender regularly tapering outline.

Size: Height : 0.33mm

Width : 0.17mm

Distribution: this species has its highest occurrence in the Late Maastrichtian (Zone F.I.1) of all the studied wells and is recorded commonly throughout the sections.

Praebulimina obtusa (d'Orbigny 1840)

(Pl.5, fig.9)

1840 Bulimina obtusa d'Orbigny, p.39, pl.4, figs.5, 6.

non 1899 Bulimina obtusa d'Orbigny; Egger, p.50, pl.15, fig.51.

1934 Buliminella obtusa (d'Orbigny); Cushman & Parker, p.28, pl.5, fig.1.

1936 " " (d'Orbigny); Brotzen, p.131, pl.8, fig.2.

1941 " " (d'Orbigny); Marie, p.197, pl.30, fig.290.

1941 " " (d'Orbigny), f. typica Marie, p.198, pl.30, fig.291.

1946 " " (d'Orbigny): Schijsma, p.80, pl.4, fig.9.

non 1951 Buliminella obtusa (d'Orbigny); Visser, p.257, pl.2, fig.13.

1957 " cf. obtusa (d'Orbigny); McGugan, p.341, pl.32, fig.9.

p.1957 Buliminella obtusa (d'Orbigny); McGugan, p.341, pl.32, figs.5,6, non figs.7, 8.

1964 " " (d'Orbigny); McGugan, p.934, pl.150, fig.26.

1966 " " (d'Orbigny); Barr, pp.499-500, pl.77, fig.3.

1977 " " (d'Orbigny); Villain, p.71.

1981 Praebulimina obtusa (d'Orbigny); Hart et al. in Jenkins & Murray, p.214, pl.7.21, fig.3.

Description: test free, large, two variants are present; one is initially bluntly pointed, increasing rapidly in size; chambers arranged trochospirally in four to five whorls, the last whorl occupying nearly two-thirds of the test; chambers slightly inflated, four to a whorl; sutures flush; the other variant is initially broadly rounded and extremely rapidly flaring, with the last whorl parallel sided and occupying more than two-thirds of the test and more inflated than the other variant; aperture loop-shaped and set in a distinct depression; apertural face distinctly overlapping previous whorl; wall calcareous, surface smooth.

Remarks: this species was originally described from the Campanian of the Paris Basin (d'Orbigny 1840). The more inflated variant is reported to replace the less inflated form in the lower levels of the mid Late Campanian (Swiecicki 1980 (unpubl.)); Hart et al. 1981). Although both variants were encountered in the present study, this apparent stratigraphic relationship is not clear because of problems with contamination by caving.

Size: Height : 0.77mm
Width : 0.53mm

Distribution: this species 'tops' within the Late Maastrichtian (Zone F.I.1) in wells 44/2-1 and 49/20-2 and is recorded uncommonly throughout these sections. The highest occurrence downhole of this species in well 49/19-1 occurs in the Late Campanian (Zone F.I.3). It

is generally uncommon in this section with the exception of the Early Campanian interval (Zone F.I.4) where it is recorded commonly to abundantly.

Praebulimina parva (Franke 1928)

(Pl.5, fig.10)

1928 Bulimina parva Franke, p.157, pl.14, fig.13.

1947 " " Franke; Cushman & Parker, pp.80-81, pl.19, fig.17.

non 1951 Bulimina parva Franke; Visser, p.258, pl.2, fig.16.

Description: test free, small, fusiform in outline; slender, twice as long as wide; chambers arranged triserially in four whorls; chambers weakly inflated and overlapping, increasing uniformly and moderately rapidly in size as added; sutures distinct and slightly depressed; aperture subterminal, trilateral slit; wall calcareous, surface smooth.

Remarks: this species is characterised by its small size and fusiform test. Hofker (1966), after re-examing Visser's specimens of B. parva from the Maastrichtian of Holland, (1951), tentatively reassigned them to P. carseyae (Plummer). Swiecicki (1980 (unpubl), has recorded this species as occurring sporadically from the basal Campanian to the late mid Campanian of the Isle of Wight, and very rarely from the Early Campanian of Norfolk.

Size: Height : 0.30mm
Width : 0.18mm

Distribution: this species 'tops' within the Late Campanian (Zone F.I.3) of well 49/20-2 and within the Early Santonian (Zone F.I.7) of well 49/19-1. It is recorded rarely throughout these two sections.

Praebulimina reussi (Morrow 1934)

(Pl.6, fig.1a,b)

1844 Bulimina ovulum Reuss, p.215, (non B. ovula d'Orbigny 1839)
?1899 " " Reuss; Egger, pp.51-52, pl.15, fig.46.
1925 " brevis d'Orbigny; Franke, p.25, pl.2, fig.18.
?1925 " ovulum Reuss; Franke, p.25, pl.2, fig.17.
1931(b) " brevis d'Orbigny, Cushman, p.40, pl.5, fig.9.
1931(b) " murchisoniana d'Orbigny; Cushman, p.309, pl.35, fig.14.
1934 " ovulum Reuss; Cushman & Parker, p.29, pl.5, figs.10,11.
1934 " brevis d'Orbigny; Dain, p.36, pl.4, fig.4.
1934 " reussi Morrow, pp.195-196, pl.29, fig.2.
1936 " " Morrow; Jennings, p.31, pl.3, fig.20.
1936 " ovula Reuss, Brotzen, pp.125-127, t.fig.42, fig.9.
1936 " ventricosa Brotzen, pp.124-127, pl.8, fig.1, t.fig.42, figs.1-8.
1941 Buliminella ovulum (Reuss) var. hemicircularis Marie, p.202, pl.31, fig.296.
1941 " ovulum (Reuss) var. triangularis Marie, p.202, pl.31, figs.298, 299.
1941 " reussi Morrow; Cushman & Hedberg, p.95, pl.22, fig.30.
1951 " " Morrow; Visser, p.258, pl.2, fig.15.

1951 Praebulimina reussi (Morrow); Hofker, p.144.

1951 Buliminella ovula (Reuss); Hofker, p.123, figs.73, 74.

1956 Bulimina reussi Morrow; Said and Kenawy, p.143, pl.4, fig.15.

p1957 Praebulimina reussi (Morrow); Hofker, pp.187-188, t.fig. 227, nos. 1-3, non nos. 4,5.

1957 " ovulum (Reuss); Hofker, p.184.

1957 " ventricosa (Brotzen); Hofker, pp.184-186, t.figs.223, 224.

1961 Bulimina reussi Morrow; Vasilenko, pp.174-176, pl.38, figs.2a-b, 7a-b.

1964 Praebulimina reussi (Morrow); Loeblich & Tappan, p.C545, fig.428, 1-3.

1968 " reussi (Morrow); Sliter, p.85, pl.12, figs.1,2.

1972 " " (Morrow); Hanzlikova, p.77, pl.18, fig.16.

1981 " " (Morrow); Hart et al. in Jenkins & Murray, p.214, pl.7.21, figs.5,6.

Description: test free, ovate, increasing rapidly and uniformly in size to the greatest width above the mid-point of the test; chambers triserially arranged in four to five whorls; chambers initially weakly inflated but becoming rapidly inflated, elongate and overlapping, sutures distinct and slightly depressed; aperture variable but commonly a narrow terminal slit at inner margin of final chamber; wall calcareous and finely perforate, surface smooth.

Remarks: this species is highly variable and has been much confused in the literature. The original name B. ovulum proposed by Reuss (1844), is a junior homonym of the recent benthic B. ovula d'Orbigny 1839, described from South America; the name B. reussi was proposed for Reuss's species by Morrow in 1934.

Size: Height : 0.35mm
Width : 0.25mm

Distribution: this species 'tops' within the Early Maastrichtian (Zone F.I.2) of well 44/2-1, and within the Early Santonian (Zone F.I.7) of well 49/19-1. It is recorded rarely and sporadically throughout these two well sections.

Genus PYRAMIDINA Brotzen 1948

Type species Bulimina? curvisuturata Brotzen 1940

Pyramidina trigonia (Chapman 1892)

(Pl.6, fig.2a,b)

1892 Bulimina trigonia Chapman, p.515, pl.15, fig.8.

1964 " " Chapman; Barr & Cordey, p.308, pl.49, fig.5-7.

Description: test free, small and triangular, initially broadly rounded to pointed; cross-section triangular with broadly rounded edges and concave sides; chambers indistinct, triserial, arranged in five to six whorls, initially inflated becoming subglobular; sutures

indistinct, slightly depressed to flush; aperture a loop shaped opening at the inner margin of the final chamber; wall calcareous and finely perforate, surface ornamented by small pits.

Remarks: this species was originally described from the Upper Santonian chalk of Taplow, England (Chapman 1892), and has since been recorded from Norfolk, the Isle of Wight and the North Sea Basin by Swiecicki (1980 (unpubl.)).

P. trigonia appears to be very similar to P. triangularis (Cushman & Parker, 1935), described from the Campanian of the U.S.A., and it is possible that some confusion between these two species may exist in the literature.

Size: Height : 0.31mm
Width : 0.21mm

Distribution: this species has its highest occurrence within the Early Maastrichtian (Zone F.I.2) of well 44/2-1 and within the mid Campanian (Zone F.I.4) of well 49/19-1. It is recorded very rarely and sporadically throughout these two sections.

Family BOLIVINITIDAE Cushman 1927

Genus BOLIVINA d'Orbigny 1839

Type species Bolivina plicata Cushman 1911

Bolivina incrassata Reuss 1851

(Pl.6, fig.3a,b)

1851 Bolivina incrassata Reuss, p.45, pl.4(5), fig.13.

1925 " " Reuss; Franke, p.21, pl.2, fig.8.

1926b " " Reuss; Cushman, p.19, pl.2, fig.1.

1928 " " Reuss; Franke, p.153, pl.14, fig.6.

non 1941 Bolivina incrassata Reuss, var. limonensis Cushman; Marie, p.205, pl.32, figs.303-305.

1946 " " Reuss; Schijfsma, pp.77-78, pl.6, fig.9.

1949 " " Reuss; Wicher, p.84, pl.5, fig.1.

1949 " " Reuss f. gigantea Wicher, p.85, pl.5, figs.2,3.

1954 " " Reuss; Frizzell, p.117, pl.17, fig.25.

1955 " " Reuss; Bettenstaedt & Wicher, p.502, pl.2, fig.16.

1955 " " Reuss, gigantea Wicher, Bettenstaedt & Wicher, p.502, pl.2, fig.19.

1957 " " Reuss; McGugan, pp.340-341, pl.32, figs.1-4.

1957 " " Reuss; Hofker, p.228, t.figs.282-286, 291.

1960 " " gigantea Wicher; Hiltermann & Koch, p.75, pl.3.

1962 " " Reuss; Hiltermann & Koch, p.312, pl.51, figs.14,15.

1962 " " gigantea Wicher; Hiltermann & Koch, p.312, pl.51, figs.16,17.

1964 " " Reuss; McGugan, pp.942-943, pl.150, figs.22,23.

1966 ___"___ ___"___ Reuss; Hofker, p.39, pl.5, fig.42, pl.10, figs.90,91.

1968 ___"___ ___"___ Reuss; Sliter, p.88, pl.12, fig.14.

1968 ___"___ ___"___ gigantea Wicher; Sliter, p.88, pl.12, fig.15.

1969 ___"___ ___"___ Reuss; Hanzlikova, p.31, pl.5, figs.7,8.

1972 ___"___ ___"___ Reuss; Hanzlikova, p.80, pl.19, figs.5,6.

1972 ___"___ ___"___ crassa Vasilenko & Myatliuk; Hanzlikova, p.80, pl.19, fig.4.

1977 ___"___ plicata Carsey; Villain, p.68, pl.5, fig.16.

1977 ___"___ incrassata incrassata Reuss; Koch, p.54, pl.14, figs.5,6.

1977 ___"___ ___"___ crassa Vasilenko & Myatliuk; Koch, p.54, pl.14, figs.3,4.

1977 ___"___ ___"___ gigantea Wicher; Koch, pp.54-55, pl.14, figs.1,2.

1981 ___"___ ___"___ Reuss; Hart et al. in Jenkins & Murray, p.180, pl.7.4, figs.8,9.

Description: test free, elongate and varying in outline from a long slender form to one that is stout and robust with the widest point of the test close to the apertural end; test compressed, periphery subrounded, outline entire to slightly lobate; megalospheric forms broadly rounded and almost parallel sided, microspheric forms pointed and uniformly expanding; chambers numerous and slightly inflated, commonly eight to twelve; sutures distinct and slightly depressed, steeply inclined; aperture an elongate, wide oval shaped opening extending from the interiomarginal suture of the last chamber, up the apertural face; wall calcareous and finely perforate, surface smooth.

Remarks: the highly variable nature of this species has led to the recognition of many subspecies (e.g. Wicher 1949; Vasilenko & Myatliuk 1947), which have been variously interpreted by later workers (e.g. Hanzlikova 1972; Koch 1977), and this has resulted in much confusion regarding the stratigraphic distribution of the various forms. It may be that ecological factors strongly influence the stratigraphic distribution of these forms (Sliter 1968); morphological variation within the genus due to ecological controls has been demonstrated by Lutze (1964). These results, and differing stratigraphical ranges recorded for the subspecies of B. incrassata makes the formal recognition of subspecies impossible at present.

Size: Megalospheric form: Height : 0.92mm
Width : 0.44mm
Microspheric form: Height : 0.88mm
Width : 0.25mm

Distribution: this species 'appears' downhole as part of the Early Maastrichtian (Zone F.I.2) faunas in all three well sections. It is recorded rarely throughout wells 49/19-1 and 49/20-2, but commonly or abundantly throughout well 44/2-1.

Genus BOLIVINOIDES Cushman 1927

Type species Bolivina draco Marsson 1878

Bolivinoides australis Edgell 1954

(Pl.6, fig.4.)

1954 Bolivinoides decorata (Jones) australis Edgell, pp.71-72, pl.13, figs. 5,6, pl.14, figs.5,6.

1955 " australis Edgell; Hofker, p.71, t.fig.c-c.

1958 " decorata australis Edgell; Bieda, pp.33-34, t.fig.7.

1959 " australis Edgell; Hofker, p.71, pl.13, figs.5,6.

non 1965 " " Edgell; Goel, p.82, pl.7, figs.14,15.

1966a " " Edgell; Barr, pl.34, fig.1, pl.35, figs.1-3.

1966 " " Edgell; Hofker, p.39, pl.5, figs.29,30, pl.10, figs.79-87, pl.13, figs.37-42.

non 1977 " " Edgell; Sliter, pl.5, figs.5,6.

Description: test free, elongate and subrhomboid in outline with the widest point of the test towards the apertural end; periphery subrounded to slightly lobate; test rapidly and uniformly expanding; proloculus globular, followed by five to seven pairs of biserial, slightly inflated chambers; sutures indistinct and oblique, obscured by strongly developed elongate lobes, perpendicular to sutures; aperture narrow, loop-shaped and subterminal; wall calcareous and perforate.

Remarks: Bolivinoides australis is morphologically intermediate between B. decoratus (Jones 1875) and B. giganteus Hiltermann & Koch 1950. It can be distinguished from the ancestoral B. decoratus by its

broader outline and by the uniform nodose ornament covering the initial 2/3's of the test, and from B. giganteus by its lack of ornamental lobes coalescing into long ridges.

Size: Height : 0.33mm
Width : 0.23mm

Distribution: rare, often broken specimens assignable to this species appear 'downhole' in the Early Maastrichtian (Zone F.I.2) of well 49/19-1 and in the Late Campanian (Zone F.I.3) of wells 49/20-2 and 44/2-1. It is only recorded very rarely in these sections.

Bolivinoides culverensis Barr 1967

(Pl.6, fig.5.)

1954 Bolivinoides decoratus (Jones) cf. delicatula Cushman, Edgell, p.71, pl.13, fig.7, pl.14, fig.7.
1955 " strigillatus (Chapman); Hofker, pl.1, fig.a.
1963 " sp., Hiltermann, p.209, pl.1, figs.2,3,7-9.
1966a " hiltermanni Barr, pp.229-230, pl.36, figs.7, 8, pl.37, figs.1-3.
1967 " culverensis Barr, p.136.
1977 " " Barr; Peters, pp.1031-1032, pl.1, figs.10-12.
pl1977 " decoratus decoratus (Jones); Koch, p.51, pl.12, fig.5.
p1977 " strigillatus (Chapman); Govidan; pp.469-470, t.fig.10c.

1981 " culverensis Barr; Hart et al. in Jenkins & Murray, p.180, pl.7.4, figs.10,11.

Description: test free, elongate and moderately flaring, with the widest point of the test towards the apertural end; periphery subrounded, cross-section compressed and ovoid; proloculus subglobular, followed by seven to eight pairs of biserial, oblique chambers; sutures indistinct, oblique and slightly curved, obscured by strongly developed, broad, elongate lobes, usually three per chamber, perpendicular to sutures, initial portion of test possessing only faintly raised nodules; wall calcareous and perforate.

Remarks: B. culverensis is morphologically intermediate between B. strigillatus (Chapman 1892) and B. decoratus (Jones 1875). It may be distinguished from the ancestoral B. strigillatus by its broader and more compressed test, and generally larger and more rapidly flaring form. Swiecicki (1980 (unpubl.)) has recorded transitional forms between these two in the late Early Campanian.

Size: Height : 0.50mm
Width : 0.23mm

Distribution: this species has only been recorded from well 49/19-1 where it 'tops' within the mid Campanian (Zone F.I.3) interval. It is found extremely rarely.

additional note; B.hiltermanni Barr, 1966 - while this initial paper was in press Goel (1965) published his paper in which he used the name B.hiltermanni and therefore this would have priority for the name. Barr subsequently re-named his species B.culverensis.

Bolivinoides decoratus (Jones 1875)

(Pl.6, fig.6)

1875 Bolivina decorata Jones (in Wright), pp.87, 96, 97 (list)

1926 " latticea Carsey, p.27, pl.4, fig.9.

1929 " decorata Jones; White, p.43, pl.5, fig.1.

1932 Bolivinoides decorata (Jones); Sandridge, p.196, pl.19, fig.16.

1941 " " (Jones) f.typica Marie, p.188, pl.29, fig.279.

non 1946 Bolivinoides decorata (Jones); Cushman, p.113, pl.48, figs.8,9.

p1946 " " (Jones), var. delicatula Cushman; Cushman, p.113, pl.48, figs.11, 12, non 10,13,14.

1948 Bolivina strigillata Chapman; Williams-Mitchell, p.106, pl.9, fig.3.

1950 Bolivinoides decorata decorata (Jones); Hiltermann & Koch, pp.606-610, t.figs.2-4, nos.17-25, 27-31, 35-38, 42-45.

1954 " " " (Jones); Reiss, p.155, pl.28, figs.5-8.

1954 " regularis Reiss, p.158.

p1954 " decorata latticeus (Carsey); Frizzell, p.112, pl.16, fig.18, non.fig.19.

non 1954 " " decorata (Jones); Frizzell, p.111, pl.16,fig.17.

1956a " " " (Jones); Hofker, p.B207, fig.8.

p1957 " " " (Jones); McGugan, p.339, pl.32, figs.10,13,?14,15, non 11,12.

1958 " " " (Jones); Witwicka, pp.198-199, pl.9, fig.9.

1961 " " " (Jones); Vasilenko, pp.189-190, pl.39, figs.8-10, t.fig.21 (2a).

1962 " decoratus decoratus (Jones); Hiltermann & Koch, p.315, tab.19, pl.46, fig.7.

1963 " decorata decorata (Jones); van Hinte, p.105, pl.14, figs.1,2.

1965 " ellipsodecorata Goel, p.81, pl.7, fig.13.

1965 " rhombodecorata Goel, p.80, pl.7, figs.9,10.

1965 " australis Edgell; Goel, p.82, pl.7, figs.14,15.

1966 " decorata decorata (Jones); Hofker, p.27, pl.3, fig.50.

1966a " " (Jones); Barr, pp.231-232, pl.34, figs.2-6, 12, pl.35, figs.6-9, pl.36, figs.1-5.

1970 " cf. decoratus (Jones); Barr, p.647, pl.100, figs.1-3, t.fig.5.

1972 " " (Jones); Hanzlikova, pp.80-81, pl.19, figs.7-9.

1977 " " (Jones); Villain, p.69, pl.5, fig.4.

1977 " " (Jones); Petters, p.1032, pl.1, fig.2.

p1977 ___" ___" decoratus (Jones); Koch, p.51, pl.12, fig.6, non fig.5.

?1977 ___" australis Edgell; Sliter, pl.5, figs.2,3.

1981 ___" decoratus decoratus (Jones); Gazdzicka, p.83, pl.22, fig.8.

1981 ___" ___" (Jones), Hart et al. in Jenkins & Murray, p.180, pl.7.4, fig.12.

Description: test free, elongate and rhomboid in outline with the widest point of the test varying between mid-way and the apertural end; periphery subrounded, cross-section compressed and elliptical; proloculus globular, followed by seven to nine pairs of biserial, slightly inflated chambers; sutures indistinct and oblique, obscured by strongly developed ornamental lobes, often coalescing across two chambers, perpendicular to sutures, most strongly developed on the later chambers-initial portion of the test is much less ornamented and may only possess irregular nodules; aperture a narrow, loop shaped opening; wall calcareous and perforate.

Remarks: Bolivinoides decoratus is morphologically intermediate between B. culverensis Barr 1967 and B. australis Edgell 1954. It may be distinguished from the ancestral B. culverensis by its more rapidly expanding test and more strongly developed ornament, and from B. australis by its wider, larger, more rapidly flaring outline with a greater development of ornamental lobes.

This widely recorded species has often been confused with B. miliaris Hiltermann and Koch 1950 (e.g. Cushman 1946), and B. australis (eg. Goel, 1965; Sliter 1977). The taxonomic position of this species has been clarified by the erection of a lectotype by Barr (1966).

Swiecicki (1980 (unpubl)), has recorded transitonal forms between B. culverenesis and B. decoratus in the uppermost mid Campanian.

Size: Height : 0.68mm
Width : 0.42mm

Distribution: this species has its highest occurrence within the Early Maastrichtian (Zone F.I.2) of well 49/20-2 and within the Late Campanian (Zone F.I.3) of wells 44/2-1 and 49/19-1. It is recorded only rarely in the material studied.

Bolivinoides draco (Marsson 1878)
(Pl.6, fig.7)

1878 Bolivina draco Marsson, p.157, pl.3, fig.25.
non 1925 " " Marsson; Franke, p.20, pl.2, fig.4.
1926b " rhomboidea Cushman, p.19, pl.2, fig.3.
1927 Bolivinoides rhomboidea (Cushman); Cushman, p.90, pl.12, fig.10.
non 1928 Bolivina draco Marsson; Franke, p.151, pl.14, fig.2.
1929 Bolivinoides draco (Marsson); White, p.45, pl.5, fig.2.
1940 " dorreeni Finlay, p.453, pl.63, figs.56-58.
1946 " rhomboidea (Cushman); Cushman, p.113, pl.48, fig.15.

1950 " draco draco (Marsson); Hiltermann and Koch, p.598, t.figs. 1-5, figs.52-54, 58-60, 69, 72-73.

1954 Bolivinoides draco draco (Marsson); Reiss, p.155, pl.29, figs.1-3.

1954 " " dorreeni Finlay; Reiss, p.153, pl.29, figs.4-7.

1956 " " draco (Marsson); Said and Kenawy, p.140, pl.3, fig.41.

1956 " " dorreeni Finlay; Said and Kenawy, p.140, pl.3, fig.42.

1957 " " draco (Marsson); McGugan, p.335, (list), pl.32, fig.17.

1962 " " " (Marsson); Hiltermann and Koch, p.318, pl.46, fig.18.

1964 " " (Marsson); Loeblich and Tappan, p.C549-552, fig.435, 1,2.

1966 " " (Marsson); Hofker, p.73, pl.13, figs.34-36.

1968 " " draco (Marsson); Sliter, p.88, pl.12, fig.17.

?1968 " " miliaris Hiltermann & Koch; Sliter, p.88, pl.12, fig.16.

1968 " " " (Marsson); Koch, p.654, t.fig.62.

1970 " " (Marsson); Barr, p.646, pl.99, figs.2,3.

1972 " " (Marsson); Hanzlikova, p.81, pl.19, fig.10,11.

1977 " " (Marsson); Villain, p.69, pl.5, fig.13.

1977 " " (Marsson); Petters, p.1032, pl.1, fig.1.

1977 " " draco (Marsson); Koch, pl.12, figs.2,3.

1977 " " (Marsson); Govindan, p.473, pl.2, fig.15, t.fig.10n-c.

1981 " " (Marsson); Hart et al. in Jenkins & Murray, p.180, pl.7.4, fig.13.

Description: test free, elongate and rhomboid in outline with the widest point of the test towards the apertural end; periphery sub-acute to acute, cross-section elliptical and compressed; proloculus globular, followed by six to seven pairs of biserial, slightly curved chambers; sutures indistinct and oblique, obscured by strongly developed, broad, elongate lobes, four per chamber, coalescing into longitudinal ribs, separated by a median sulcus; aperture a wide, loop-shaped opening bordered by a thin lip; wall calcareous and perforate.

Remarks: B. draco is characterised by the regular rhomboid test and the longitudinal costae forming two vertical ribs that extend the length of the test, thus distinguishing it from its ancestral B. miliaris Hiltermann & Koch 1950.

Size: Height : 0.34mm
Width : 0.31mm

Distribution: rare often broken specimens referable to this species are first recorded 'downhole' within the Late Maastrichtian (Zone F.I.1) of well 44/2-1. It is recorded from only one sample from well 49/20-2 within the Early Maastrichtian (Zone F.I.2); the occurrence at this level is thought to be unusual and is probably explained by 'caving'.

Bolivinoides laevigatus Marie 1941

(Pl.6, fig.8)

1941 Bolivinoides decorata (Jones) var. laevigata Marie, p.189, pl.29, fig.281.

1952 " " laevigata Marie; Hiltermann, p.63, t.figs.4,5.

?1954 " compressa Reiss, p.156, pl.30, figs.1-3.

?1954 " praecursor Reiss, p.156, pl.30, figs.4-7.

1954 " sp. Reiss, p.157, pl.29, fig.11.

1955 " laevigata Marie, Hiltermann & Koch, pp.367-368, pl.27.

1958 " praecursor Reiss; Bieda, pp.41-42, t.fig.12.

1960 " laevigata Marie; Hiltermann & Koch, p.72, tab.3.

1961 " laevigatus laevigatus Marie; Vasilenko, p.197, pl.40, figs.2,3. t.fig.21(7b).

1962 " " Marie, Hiltermann & Koch, p.316, pl.51, fig.10.

1963 " delicatulus Cushman; Graham & Church, p.51, pl.5, fig.24.

?1965 " praecursor Reiss; Goel, pp.79-80, pl.7, fig.8.

1965 " compressa Reiss; Goel, p.82, pl.7, fig.16.

1965 " laevigatus Marie; Goel, p.83, pl.7, fig.19.

1966a " laevigata Marie, Barr, p.237, pl.34, fig.7, pl.38, figs.1-5.

?1970 Bolivinoides cf. laevigatus Marie; Barr, p.648.

1975 " " Marie; Koch, p.209, pl.1, fig.3.

1977 " " Marie; Petters, p.1033,-34, pl.1, fig.4.

1977 " " Marie; Koch, p.52, pl.13, fig.7.

1981 " " Marie; Hart et al. in Jenkins & Murray, p.182, pl.7.5, figs.1,2.

Description: test free, elongate with the widest part of the test towards the apertural end; periphery subacute, cross section compressed and elliptical; proloculus globular, followed by seven to nine pairs of biserial, slightly inflated, curved chambers; sutures distinct, slightly depressed, oblique and curved; aperture a narrow, loop-shaped opening extending up the apertural face, bordered by a lip; wall calcareous, surface weakly ornamented by circular to elongate nodes, two to three per chamber, restricted to the median part of the test.

Remarks: this is a small, distinctive and weakly ornamented member of the genus Bolivinoides.

Size: Height : 0.46mm
Width : 0.20mm

Distribution: this species has been recorded only very rarely from the studied material 'topping' within the Late Maastrichtian (Zone F.I.1) of well 49/20-2 and within the Late Campanian (Zone F.I.3) of well 44/2-1.

Bolivinoides miliaris Hiltermann & Koch 1950

(Pl.6, fig.9)

1927 Bolivinoides decorata (Jones); Cushman, p.89, pl.12, fig.9.

1950 " draco (Marsson) milaris Hiltermann & Koch, pp.604-606, t.figs.2-4, nos. 32-34, 39-41, 46-48, t.fig.5, no.39.

1954 " " miliaris Hiltermann & Koch; Reiss, p.155, pl.28, figs.9-12, 14.

1955 " " " Hiltermann & Koch; Hiltermann & Koch, p.365, t.figs.28,9.

1957 " cf. B. draco (Marsson); McGugan, pl.32, fig.16.

1958 " draco miliaris Hiltermann & Koch; Witwicka, p.199, pl.9, fig.11.

1961 " miliaris Hiltermann & Koch; Vasilenko, pp.200-201, pl.40, fig.4, pl.41, fig.1.

1963 " draco miliaris Hiltermann & Koch; van Hinte, pp.106-107, pl.13, figs.7,8.

1964 " " " Hiltermann & Koch; Beckmann & Koch, pp.44-45, pl.6, figs.21-23.

1966a " miliaris Hiltermann & Koch, Barr, pp.234-235, pl.35, figs.4,5.

1968 " draco miliaris Hiltermann & Koch; Sliter , p.89, pl.13, fig.1.

1970 " miliaris Hiltermann & Koch; Barr, p.650, pl.99, fig.1.

1977 " draco miliaris Hiltermann & Koch; Koch, pp.56-57, pl.12, fig.4.

1977 " miliaris Hiltermann & Koch; Petters, p.1034, pl.1, fig.3.

1977 " " Hiltermann & Koch; Govindan, p.472, t.figs. 10h, 1-m.

1981 " " Hiltermann & Koch; Hart et al. in Jenkins & Murray, p.182, pl.7.5, fig.3.

Description: test free, elongate and kite shaped in outline with the widest point of the test just above mid-point; periphery subacute to acute, cross-section compressed and almost rhomboid, proloculus globular followed by seven to eight pairs of biserial, slightly inflated and oblique chambers; sutures distinct at the periphery, indistinct and obscured by the ornament medianly; aperture a loop-shaped opening extending up the apertural face, occasionally bordered by an indistinct lip; wall calcareous and perforate surface strongly ornamented medianly, initially by subcircular pustules forming two well defined, discontinuous median rows separated by a median sulcus, later ornament consists of elongate, narrow lobes, commonly three per chamber.

Remarks: Bolivinoides miliaris is morphologically intermediate between B. decoratus (Jones 1875) and B. draco (Marsson 1878). It can be distinguished from the ancestral B. decoratus by its shorter, more rhomboid outline and the characteristic development of two discontinuous median ridges, and from B. draco by the lack of continuous median ridges. Swiecicki (1980 (unpubl.)) noted that the latter two species were intergradational in his record of transitional forms from the late Early Maastrichtian of Trimingham, Norfolk. Transitional forms were also noted in the present study.

Size: Height : 0.46mm
Width : 0.38mm

Distribution: this species 'tops' in the Early Maastrichtian (Zone F.I.2) of all three studied well sections, and is recorded only rarely in the recovered microfaunas.

Bolivinoides strigillatus (Chapman 1892)

(Pl.6, fig.10)

1892 Bolivina strigillata Chapman, p.515, pl.15, fig.10.

1937 Bolvinoides austiniana Cushman, p.104, pl.15, fig.10.

non 1948 Bolivina strigillata Chapman; Williams-Mitchell, p.106, pl.9, fig.3.

1950 Bolivinoides " (Chapman); Hilterman & Koch, pp.614-623, t.figs. 2(1-19), 3(1-9), 5(10).

1954 " austrinianus Cushman; Frizzell, p.111, pl.16, fig.16.

non 1955 " strigillata (Chapman); Hofker, pl.1, fig.a.

1958 " " (Chapman); Witwicka, pp.196-198, pl.9, fig.8.

1960 " " (Chapman); Belford, p.61, pl.15, figs.14-18.

1961 " " (Chapman); Vasilenko, pp.186-188, pl.39, fig.7.

1962 " " (Chapman); Hiltermann & Koch, p.314, pl.48, figs.10,11.

1964 " " (Chapman); Barr & Cordey, pp.308-309, pl.49, figs.1-3.

1966a ___"___ (Chapman); Barr, p.228-229, pl.34, figs.8,9, pl.37, figs.7-9.

1968 ___" strigillatus (Chapman); Bettenstaedt, p.346, t.fig.3.

1970 ___"___ (Chapman); Barr, pp.651-652, t.fig.7, pl.100, figs.6,7. t.figs.2,7.

1975 ___"___ (Chapman); Koch, p.207, pl.1, fig.1.

1977 ___"___ (Chapman); Sliter, p.674, pl.5, figs.5,6.

1977 ___"___ (Chapman); Petters, p.1035, pl.1, fig.9.

1977 ___"___ (Chapman); Koch, pp.44-45, pl.12, figs.7.8.

1977 ___"___ (Chapman); Govindan, pp.469-470, pl.1, figs.1-8, pl.2, fig.13, t.fig.10a,b. non c.

1981 ___"___ (Chapman); Hart et al. in Jenkins & Murray, p.182, pl.7.5, fig.8.

Description: test free and elongate with the widest portion of the test very close to the apertural end; periphery subrounded to cross-section slightly compressed and subcircular; proloculus subglobular, followed by six to eight pairs of biserial, slightly inflated and inclined chambers; sutures indistinct and slightly oblique obscured by two to three raised ornamental lobes, extending the length of each chamber, perpendicular to the sutures; aperture a narrow, loop-shaped opening, bordered by an indistinct lip extending up the apertural face; wall calcareous and perforate.

Remarks: this species was originally described from the Upper Santonian phosphatic chalk of Taplow, England (Chapman 1812), and can be distinguished by its small size, gradually flaring test, the less numerous ornamental lobes and the uncompressed, subcircular cross-section. After re-examining Chapman's type material deposited in the British Museum (Nat. Hist.), Barr & Cordey (1964) erected a lectotype (P.44968) for this species.

Size: Height : 0.50mm
Width : 0.25mm

Distribution: rarely recorded from the studied material, this species 'tops' within the Early Campanian (Zone F.I.5) of wells 44/2-1 and 49/20-2, and within the Late Santonian (Zone F.I.6) of well 49/19-1.

Family BULIMINIDAE Jones 1875

Subfamily PAVONINAE Eimer & Fickert 1899

Genus REUSSELLA Galloway 1933

Type species Verneuilina spinulosa Reuss 1850

Reussella kelleri Vasilenko 1961

(Pl.7, fig.1)

1935 Reussella aff. spinulosa (Reuss); Keller, p.550, pl.2, figs.9-11.

p1957 " pseudospinulosa Troelsen; Hofker, pp.212-213, t.fig.260, non.t.fig.259.

1961 ____" kelleri Vasilenko, pp.176-178, pl.38, figs.3-5, 12, 13.

1975 ____" ____" Vasilenko; Robaszynski in Colbeaux et al., p.19, fig.2.

?1977 ____" pseudospinulosa Troelsen; Sliter, p.675, (list), pl.5, figs.8,11.

1981 ____" kelleri Vasilenko; Hart et al. in Jenkins & Murray, p.216, pl.7.22, figs.5,6.

Description: test free, elongate and subtriangular, initially sharply pointed, increasing uniformly and rapidly in size; cross-section triangular, edges sub-acute to angular; chambers distinct, triangular, inflated and strongly overlapping, arranged triserially in four to six whorls; sutures distinct, curved and often raised; margins spinose and occasionally with small flanges projecting from the edges; aperture a narrow straight slit extending vertically up the apertural face, surrounded by a slightly raised lip.

Remarks: this species was originally described from the Santonian of Southern Russia (Vasilenko 1961), and can be distinguished by its carinate, often slightly spinose periphery. Bailey (1978 (unpubl)). recorded specimens of this species from the Isle of Wight that are typically carinate with limbate, slightly raised sutures whilst those recorded by Swiecicki (1980 (unpubl)) from Norfolk are more elongate with a spinose periphery and raised sutures. In many of these characters they are transitional to R. szajnochae praecursor de Klasz and Knipscheer 1954 (Swiecicki 1980 (unpubl.)).

Size: Height : 0.35mm
Width : 0.22mm

Distribution: this species is recorded uncommonly in well 44/2-1, 'topping' within the Early Campanian (Zone F.I.5). It also has its highest occurrence in the Early Campanian (Zone F.I.5) in well 49/19-1 and is recorded commonly throughout the Santonian - Coniacian interval. This species 'appears' in the Early Santonian (Zone F.I.7) in well 49/20-2 where it is recorded rarely, becoming common at the base of the Coniacian.

Reussella szajnochae praecursor de Klasz and Knipscheer 1954
(Pl.7, fig.2)

1954 Reussella szajnochae (Grzybowski) praecursor de Klasz & Knipscheer, pp.603-604, t.fig.9, (p.605), fig.1.

p1957 Reussella pseudospinulosa Troelsen; Hofker, pp.212-213, t.fig.259, non.t.fig.260.

1981 " szajnochae praecursor de Klasz & Knipscheer; Hart et al., in Jenkins & Murray, p.216, pl.7.22, fig.7.

Description: test free, small and triangular, initially sharply pointed, increasing uniformly and gradually in size; cross-section triangular, edges serrate and spinose; chambers distinct, arched and raised, strongly overlying, arranged triserially in five to six whorls; sutures distinct, raised and limbate; margins spinose; aperture a

narrow slit extending up the apertural face from mid-way along the interiomarginal suture, surrounded by a raised lip; internally a toothplate developed.

Remarks: this species can be distinguished by its small size and spinose appearance.

Size: Height : 0.29mm
Width : 0.21mm

Distribution: this species is first recorded 'downhole' in the mid-Campanian (Zone F.I.4) of well 49/19-1 where it is recorded rarely becoming common in the Santonian. It 'appears' within the Early Campanian (Zone F.I.5) of well 44/2-1 where it is also recorded rarely. Rare specimens are recovered from the Coniacian only of well 49/20-2. As this species is usually only recorded from mid-Campanian-Santonian chalk (e.g. Hart et al. 1981) their presence here is thought to be a result of 'caving' from the overlying strata.

Reussella szajnochae szajnochae (Grzybowski 1896)
(Pl.7, fig.3)

1896 Verneuilina szajnochae Grzybowski, p.287, pl.9, fig.19.
1929 Bulimina limbata White, p.48, pl.5, fig.9.
1935 Reussella spinulosa (Reuss); Keller, p.550, pl.11, figs.12-14.
1937 " pseudospinulosa Troelsen, p.260.
1944 " szajnochae californica Cushman and Goudkoff, p.59, pl.10, figs.3-5.
1946 Bulimina limbata White; Cushman, p.124, pl.52, fig.5.

1951 Reussella szajnochae (Grzybowski); Noth, p.65, pl.7, fig.7.
1954 " " (Grzybowski); de Klasz & Knipscheer, pp.600-601, t.fig.1, figs.?2,?3, 4-7.
?1957 " " (Grzybowski); Hofker, p.214, t.fig.262.
1957 " truncata Hofker, p.263, t.fig.263.
1957 " pyramidalis Hofker, pp.215-216, t.fig.264.
1958 " szajnochae (Grzybowski); Pokorny, p.303, t.fig.9.
1959 " " californica Cushman & Goudkoff; Eternod Olvera, p.83, pl.3, figs.1,2.
1960 " " (Grzybowski) Belford, p.66, pl.16, figs.16-19, pl.17, figs.1-13.
1964 " " (Grzybowski); Martin, p.91, pl.12, fig.4.
1968 Pyramidina pseudospinulosa (Troelsen); Stenestad, pl.12, fig.11.
1968 Reussella szajnochae (Grzybowski); Sliter, p.87, pl.12, fig.13.
1969 " " (Grzybowski); Scheibnerova, p.54, fig.9.
1969 " " (Grzybowski); Hanzlikova, p.35, pl.6, fig.9.
1972 " " (Grzybowski); Hanzlikova, p.85, pl.20, figs.9-11.
1977 " " (Grzybowski); Sliter, p.675, pl.5, figs.9-10.
1981 " " szajnochae (Grzybowski); Hart et al., in Jenkins & Murray, p.216, pl.7.22, fig.8.

Description: test free, robust and triangular, initially sharply pointed, increasing uniformly and rapidly in size; cross-section triangular, edges sharp, serrate and spinose, sides flat to slightly concave; chambers distinct, arched, slightly inflated and strongly overlapping, arranged triserially in four to six whorls; sutures

distinct, raised, limbate and carinate and projecting from test angles to form spines; aperture a narrow straight slit extending up the apertural face from mid-way along the interiomarginal suture, bordered by a raised lip; internally a tooth plate is developed.

Remarks: this species was originally described from clays of uncertain age from boreholes near Wadowice, Poland (Hanzlikova 1972). It has often been confused in the literature with R. pseudospinulosa Troelsen 1937 from the Lower Maastrichtian of Mons Klint, Denmark. Swiecicki (1980 (unpubl.)) examined topotype material and concluded R. pseudospinulosa falls within the range of morphological variation of R. szajnochae szajnochae.

The phylogenetic development of R. szajnochae szajnochae throughout the Campanian & Maastrichtian has been outlined by De Klasz and Knipscheer (1954) and Swiecicki (1980 (unpubl.)).

Size: Height : 0.31mm
Width : 0.23mm

Distribution: this species is recorded only rarely from all the studied sections, occurring in the Late Campanian (Zone F.I.3) of wells 44/2-1 and 49/20-2. It is recorded from one sample only (1,970'-2,000') at the base of the mid Campanian (Zone F.I.4) of well 49/19-1.

Family UVIGERINIDAE Haeckel 1894

Genus PSEUDOUVIGERINA Cushman 1927

Type species Uvigerina cristata Marsson 1878

Pseudouvigerina cristata (Marsson 1878)

(Pl.7, fig.4a,b)

1878 Uvigerina cristata Marsson, p.150, pl.3, fig.20.

1945 Pseudouvigerina cristata (Marsson); Brotzen, pp.46-47, t.fig.8a,b.

1957 Reussella cristata (Marsson); Hofker, p.220, t.figs.272-274.

1958 Pseudouvigerina cristata (Marsson); Witwicka, pl.10, fig.15.

1964 " plummerae Cushman; Freiman in Subbotina et al., p.287, pl.62, figs.15-18.

1964 " cristata (Marsson); Loeblich & Tappan, p.C568, fig.448, 1-3.

1966 Reussella crista (Marsson); Hofker, p.38, pl.5, fig.36, pl.10, fig.97, pl.13, fig.47.

1968 Pseudouvigerina cristata (Marsson); Stenestad, pl.2, fig.4.

1969 " " (Marsson); Hanzlikova, p.36, pl.6, figs.7.8.

1972 " " (Marsson); Hanzlikova, p.86, pl.19, figs.18,19.

1977 " " (Marsson); Villain, p.71, pl.5, fig.5.

1981 " " (Marsson); Hart et al. in Jenkins & Murray, p.216, pl.7.22, figs.1,2.

Description: test free and elongate, initially bluntly pointed, cross-section triangular; chambers slightly inflated and overlapping with distinct, widely spaced double vertical costae at the chamber

margins; chambers arranged triserially in four to five whorls; sutures distinct, initially slightly depressed, later becoming strongly depressed; aperture terminal or subterminal at the end of a weakly developed, short neck, occasionally bordered by a lip; internal tooth plate present; wall calcareous, finely perforate, surface smooth to finely hispid.

Remarks: the widely spaced double costae characterise this species.

Size: Height : 0.52mm
Width : 0.23mm

Distribution: this species has only been recorded rarely from well 49/19-1 where it 'tops' within the Late Campanian (Zone F.I.3).

Pseudouvigerina rugosa Brotzen 1945
(Pl.7, fig.5a,b)

1945 Pseudouvigerina rugosa Brotzen, p.47, pl.1, fig.7.
1957 Reussella rugosa (Brotzen); Hofker, pp.218-219, t.figs.268-270.
1966 " " (Brotzen); Hofker, p.38, pl.5, fig.31.

Description: test free, elongate and triangular occasionally with axial twisting, initially bluntly pointed; cross-section triangular, edges subacute and sides concave; chambers distinct, broader than high, arranged triserially in four to six whorls; sutures distinct and

weakly depressed; aperture subterminal to terminal, circular to elliptical opening at end of final chamber; wall calcareous and finely perforate, surface finely hispid.

Remarks: this species was originally described from the Lower Maastrichtian of Sweden (Höllviken) and has since been recorded from the Maastrichtian of Holland and N.W.Germany (Hofker, 1957, 1966) and from Trimingham, Norfolk (Swiecicki 1980 (unpubl). Swiecicki (1980 (unpubl.)) reassigned this species from a Reussella to the genus Pseudouvigerina on the basis of the non-carinate chamber margins; this is followed in the present study.

Size: Height : 0.34mm
Width : 0.19mm

Distribution: this species occurs rarely and sporadically in the samples from wells 49/19-1 and 49/20-2, having its highest occurrence in the mid Campanian (Zone F.I.4) and the Early Maastrichtian (Zone F.I.2) respectively.

Superfamily DISCORBACEA Ehrenberg 1838

Family DISCORBIDAE Ehrenberg 1838

Subfamily BAGGININAE Cushman 1927

Genus VALVULINERIA Cushman 1926

Type species Valvulineria californica Cushman 1926

Valvulineria lenticula (Reuss 1845)

(Pl. 7, fig.6a,b,c.)

1845 Rotalia lenticula Reuss, p.35, pl.12, fig.17.

1899 Discorbina lenticula (Reuss); Egger, p.166, pl.18, figs.22-24.

1925 Anomalina " (Reuss); Franke, p.87, pl.7, fig.15.

1936 Valvulineria " (Reuss); Brotzen, pp.151-153, pl.11, fig.5, t.fig.54,55.

non 1941 Ceratobulimina lenticula (Reuss); Marie, pp.226-227, p.35, figs.326-328.

1957 Valvulineria " (Reuss); Hofker, pp.380-381, t.fig.425.

1957 " " (Reuss); Harris & McNulty, pp.866-867, pl.97, figs.1-5.

1960 " " (Reuss); Belford, p.75, pl.20, figs.3-10.

1961 " " var. lenticula (Reuss); Vasilenko, p.43, pl.8, fig.1.

1973 " " (Reuss); Koch, p.211.

1977 " " (Reuss); Sliter, pl.6, figs.1,4.

1980 " " (Reuss); Gawor-Biedowa, pp.31-32, pl.5, figs.1,2.

1981 " " (Reuss); Hart et al. in Jenkins & Murray, p.222, pl.7.25, figs.8,9.

Description: test free, low trochospire, biconvex with rounded periphery; chambers indistinct but distinct in the final whorl, weakly inflated ventrally and increasing gradually and uniformly in size; sutures initially indistinct, becoming distinct, straight to slightly

curved and flush, becoming slightly depressed between the last two or three chambers ventrally, flush and slightly curved, becoming depressed, dorsally; aperture a narrow slit along the inner margin of the last chamber; umbilical area covered by a distinct apertural flap; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the Turonian Plänermergel of Bohemia (Reuss 1845). Brotzen (1936) recorded the range of this species as Turonian to Santonian, but it has since been recorded from the Campanian and Early Maastrichtian (Swiecicki 1980 (unpubl); Hart et al. 1981).

This species (and its variants) has been described in great detail by Harris and McNulty (1957).

Size: Diameter : 0.21mm
Thickness : 0.16mm

Distribution: this species 'appears' downhole in the Late Maastrichtian (Zone F.I.1) of well 44/2-1 and in the Late Campanian (Zone F.I.3) of well 49/19-1. It is recorded rarely to commonly throughout the studied well sections.

Family EPONIDIDAE Hofker 1951

Genus EPONIDES De Montfort 1808

Type species Nautilus repandus Fichtel & Moll 1798

Eponides beisseli Schijfsma 1946

(Pl.8, fig.1a,b)

1946 Eponides beisseli Schijsma, p.84, pl.4, fig.13.
1951 " " Schijsma; Visser, p.271, pl.8, fig.14.
1956(a) " " Schijsma; Hofker, p.B.222, t.fig.46.
1966 " " forma primativa Hofker, p.43, pl.6, fig.57.
1977 " " Schijsma; Villain, pp.60-61, pl.8, figs.10-12.
1977 Gyroidinoides beisseli (Schijsma); Sliter, pl.10, figs.3-6.
1981 Eponides beisseli (Schijsma); Hart et al. in Jenkins & Murray, p.190, pl.7.9, figs.4,5.

Description: test free, asymmetrically biconvex, outline circular, occasionally lobate; chambers arranged trochospirally, six to seven per whorl; indistinct and covered by calcareous layers, only chambers of final whorl visible dorsally, uninflated and triangular ventrally; sutures slightly depressed; aperture a distinct narrow slit along inner margin of final chamber bordered by a thick distinct lip; wall thick, surface smooth.

Remarks: this species was originally described from the Hervian Greensand (Campanian) of Holland (Schijsma 1946). The asymmetrically biconvex test and the apertural characteristics distinguish this species from other members of the genus.

Size: Diameter : 0.45mm

Thickness : 0.26mm

Distribution: this species has its highest occurrence in the Late Maastrichtian (Zone F.I.1) of well 49/20-2, in the Early Maastrichtian (Zone F.I.2) of well 49/19-1 and in the Late Campanian (Zone F.I.3) of well 44/2-1. It is only recorded rarely and sporadically throughout the well sections.

Family CIBICIDIDAE Cushman 1927

Subfamily CIBICIDINAE Cushman 1927

Genus CIBICIDES De Montfort 1808

Type species Cibicides refulgens De Montfort 1808

Cibicides beaumontianus (d'Orbigny 1840)

(Pl.8. fig.2a.b)

1840 Truncatulina beaumontiana d'Orbigny, p.35, pl.3, figs.17-19.

1851 " convexa Reuss, pp.36-37, pl.3, fig.4.

1878 " lobatula (d'Orbigny); Marsson, p.167, pl.18, fig.38.

1899 " convexa Reuss; Egger, p.149, pl.18, figs.25-27.

1928 " beaumontiana d'Orbigny; Franke, pp,176-177, pl.16, fig.6.

1934 Cibicides beaumontiana (d'Orbigny); Brotzen, p.61.

1936 " excavata Brotzen, pp.189-190, pl.13, figs.7,8.

1941 " beaumontiana (d'Orbigny); Marie, pp.249-250, pl.37, figs.352-354.

1946 " excavata Brotzen; Schijfsma, pp.100-101, pl.6, fig.7.

1954 " (Cibicides) excavatus excavatus Brotzen; Vasilenko, pp.131-132, pl.20, figs.1-3.

1956a " beaumontianus (d'Orbigny); Hofker, p.B218, fig.37.

1957 " excavatus Brotzen; Hofker, pp.93-94, t.fig.96.

1957 " beaumontianus (d'Orbigny); Hofker, pp.94-95, t.fig.97.

1960 " excavatus Brotzen; Belford, p.111, pl.34, figs.12-16.

1961 " (Cibicides) excavatus Brotzen; Vasilenko, p.132, pl.26, figs.1-3.

1961 " (Cibicides) beaumontianus (d'Orbigny); Vasilenko, p.132, pl.26, fig.4, pl.27, fig.1.

1966 " beaumontianus (d'Orbigny); Hofker, p.51, pl.13, fig.66.

1969 " excavatus Brotzen; Hanzlikova, p.53, pl.14, fig.4.

1972 " " Brotzen; Hanzlikova, p.117, pl.34, figs.2,3.

1977 " beaumontianus (d'Orbigny); Villain, p.62, pl.9, figs.1-3.

1981 " " (d'Orbigny); Hart et al. in Jenkins & Murray, p.182, pl.7.5, figs.9,10.

Description: test attached, plano-convex or enrolled; outline extremely variable, margins distinctly rounded; chambers distinct and subglobular with five or six in the final whorl, fairly rapidly increasing in size as added; sutures distinct, depressed and straight; aperture an equatorial slit to semi-circular opening at base of final chamber, extending back along the dorsal side and following the spiral suture; wall calcareous and coarsely perforate ventrally, surface smooth to slightly roughened.

Remarks: this species was originally described from the Campanian of the Paris Basin (d'Orbigny 1840). The attached habit of this species results in a wide range of morphological variation, especially on the dorsal side along which the attachment is made. The species varies from a plano-convex form as that illustrated by d'Orbigny (1840), to a tightly coiled form as illustrated by Bailey (1978 (unpubl)). as C. beaumontanus var. A.

Size: Diameter : 0.84mm

Thickness : 0.68mm

Distribution: individuals referable to this species are found only rarely in the studied well sections, and 'appears' within the Late Maastrichtian (Zone F.I.1) of wells 44/2-1 and 49/20-2, and within the Late Campanian (Zone F.I.3) of well 49/19-1.

Superfamily GLOBIGERINACEA Carpenter, Parker & Jones 1862

Family HETEROHELICIDAE Cushman 1927

Subfamily HETEROHELICINAE Cushman 1927

Genus HETEROHELIX Ehrenberg 1843

Type species Spiroplecta americana Ehrenberg 1844

Heterohelix complanata (Marie 1941)

(Pl.9, figs.1a,b)

1941 Gumbelina complanata Marie, p.184, pl.28.

1969 Heterohelix cf. complanata (Marie); Stenestad, pp.657-658, t.fig.11.

Description: test free, moderately compressed, small and increasing moderately and uniformly in size; periphery weakly lobate; cross-section bi-lobed and subrectangular; chambers arranged

biserially, ten to twelve in number, moderately inflated and broader than high; sutures distinct, straight, inclined and slightly depressed; aperture a low arch on the inner margin of the final chamber; wall calcareous and perforate, surface covered with weakly developed striations.

Remarks: this species was originally described by Marie (1941) from the Campanian of the Paris Basin. Its compressed, weakly striate test and broad chambers serve to distinguish it from H. striata (Ehrenberg 1840).

This species has also been recorded from the Upper Campanian and Maastrichtian of Denmark (Stenestad 1969), Norfolk and the North Sea (Sweicicki (1980 unpubl)).

Size: Height : 0.33mm
Width : 0.25mm

Distribution: this species has its highest occurrence in the Late Maastrichtian (Zone F.I.1) of well 44/2-1 and is recorded rarely from this well section. It is also recorded rarely to commonly from well 49/19-1, where it 'tops' within the mid Campanian (Zone F.I.4).

Heterohelix globulosa (Ehrenberg 1840)

(Pl.9, figs.2a,b)

1840 Textularia globulosa Ehrenberg, p.135, pl.4, figs.2,4,5,7,8.
1845 " " Reuss; Reuss, p.39, pl.XII, fig.23.
1860 " globifera Reuss, p.232, pl.13, figs.7,8.
1892 " decurrens Chapman, p.515, pl.15, fig.6.
1899 Gümbelina globulosa (Ehrenberg); Egger, p.32, pl.14, fig.43.
1925 Textularia globifera Reuss; Franke, p.11, pl.1, fig.13.
1928 " globulosa Ehrenberg; Franke, p.134, pl.12, fig.11.

1932 Pseudotextularia globulosa (Ehrenberg); Macfadyen, pl.35, fig.22.
1934 Gümbelina globulosa (Ehrenberg); Morrow, p.194, pl.29, fig.18a,b.
1946 " spinifera Cushman, p.108, pl.46, fig.15a,b.
1948 " globulosa (Ehrenberg); Williams-Mitchell, p.99, pl.9, fig.2.
1957 Heterohelix globulosa (Ehrenberg); Montanaro-Gallitelli p.137, pl.31, figs.12-15.
1967 " " (Ehrenberg); Pessagno, p.260, pl.87, figs.5-9, 11-13.
1967 " " (Ehrenberg); Bandy, p.23, t.fig.12.
1968 " " (Ehrenberg); Sliter, pp.94-95, pl.14, figs.1-3.
1969 " " (Ehrenberg); Douglas, pp.157-158, pl.11, fig.12.
1977 " " (Ehrenberg); Petters, p.175, pl.1, figs.11-12.
1981 " " (Ehrenberg); Frerichs & Dring, pl.1, figs.9-10.
1982 " " (Ehrenberg); Oláníyì Odébòdé; pp.238-239, pl.1, figs.6,7.

Description: test free, small, initially increasing moderately and uniformly in size, becoming rapidly expanding in the adult stages; periphery becoming strongly lobate; cross-section bi-lobed and ovate; chambers arranged biserially, globular and increasing in size rapidly in the adult stages; sutures distinct and constricted; aperture a low semi-circular arch on the inner margin of the final chamber; wall calcareous and perforate, surface smooth to finely striate.

Remarks: the taxonomic status of Heterohelix globulosa is uncertain and there is much confusion between this species and the closely related Heterohelix striata (Ehrenberg) (see remarks under H. striata). The only thus far established morphological difference between H.

striata and H. globulosa is the apparent lack of striate in the latter species under the optical microscope (Cushman 1938), but SEM studies of seemingly smooth chambers of H. globulosa have revealed the presence of fine striae (e.g. Pessagno 1967, Gawor-Biedowa 1980). The two species may actually represent extreme morphological variants of a single species but until the true nature of the external characters of H. globulosa are known the problem remains unsolved. Douglas & Rankin (1969) present a useful discussion of this species and its close relatives.

Size: Height : 0.33mm
Width : 0.21mm

Distribution: rare individuals referable to this species are recorded from wells 49/19-1 and 49/20-2, 'topping' within the Late Santonian (Zone F.I.6). It is also recorded rarely from well 44/2-1, where it 'tops' within the Late Turonian (Zone F.I.9).

Heterohelix reussi (Cushman 1938)

(Pl.9, figs.3a,b)

1938 Gumbelina reussi Cushman, p.11, pl.2, figs.6-9.
1946 " " Cushman, p.104, pl.44, figs.18a, b, 19.
1967 Heterohelix reussi (Cushman); Pessagno, p.263, pl.85, figs.1-9, pl.86, figs.1-2.
1969 " " (Cushman); Douglas, pp.158-159, pl.11, fig.15.
1969 " " (Cushman); Douglas & Rankin, pp.191-192, fig. 5a, b.
1970 " " (Cushman); Porthault, in Donze et al. pp.61-62, pl.9, figs.1-3.
?1977 " " (Cushman); Petters, pl.1, fig. 14.
1981 " " (Cushman); Frerichs & Dring, pl.1, figs.1,2.

1982 " " (Cushman); Olániyì Odébodé, p.242, pl.2, figs. 11, 12.

Description: test free, small and increasing moderately and uniformly in size; periphery weakly lobate; cross-section bi-lobed and subrectangular; chambers arranged biserially, globular and rapidly increasing in size; sutures distinct, strongly constricted resulting in depressed triangular areas around the central suture; aperture an interiomarginal semi-circular low arch; wall calcareous and perforate, surface rugose to slightly striate.

Remarks: this species was originally described by Cushman (1938) from the Austin Chalk (Campanian). Cushman originally stated that the surface of this species is smooth and finely perforate, but after examining the holotype and paratypes, Pessagno (1967) reported the presence of very fine costae.

H. reussi is similar to H. globulosa (Ehrenberg) but can be distinguished from it by the presence of triangular depressions about the central suture, and the compressed nature of the chambers.

Size: Height : 0.37mm
Width : 0.25mm

Distribution: this species has its highest occurrence within the Late Santonian (Zone F.I.6) of wells 49/19-1 and 49/20-2, and within the Early Santonian (Zone F.I.5) of well 44/2-1. It is recorded only rarely and sporadically throughout the well sections.

Heterohelix striata (Ehrenberg 1840)

(Pl.9, figs. 4a, b)

p.1840 Textularia striata Ehrenberg, p.135, pl.4, figs.1-3, non 9.

1899 Gümbelina " (Ehrenberg); Egger, p.33, pl.14, figs.5-7, 10, 11, 37-39.

1938b " " (Ehrenberg); Cushman, p.8, pl.1, figs.34-40.

1941 " globulosa (Ehrenberg) var. striatula Marie, p.182, pl.28, figs.273-275.

1946 " striata (Ehrenberg); Schijfsma, p.74, pl.4, fig.6.

1946 " " (Ehrenberg); Cushman, p.104, pl.45, figs.4,5.

1951 " " (Ehrenberg); Bandy, p.510, pl.75, figs.8,9.

1953 Pseudogümbelina striata (Ehrenberg); Bronnimann & Brown, p.154, t.fig.6.

1957 Gümbelina striata "gruppe" Hofker, pp.418-421, t.figs. 476-477.

1962a Heterohelix striata (Ehrenberg); Berggren, p.21, pl.6, figs.1-5.

1966 Gümbelina striata (Ehrenberg); Hofker, pp.31, 64, 79, pl.3, fig.68, pl.33, fig.76, pl.34, fig.105.

1967 Heterohelix striata (Ehrenberg); Bandy, pp.23-24, t.fig.12, no.9.

1967 " " (Ehrenberg); Pessagno, p.264, pl.78, figs.3-7, pl.98, fig.16.

1969 " " (Ehrenberg); Hanzlikova, p.40, pl.7, figs.13-17, 24-28.

1973 " " (Ehrenberg); Smith & Pessagno, p.19, pl.3, figs.8-11, pl.4, figs.1-4.

1977 " globulosa (Ehrenberg); Villain, p.72, pl.13, fig.6.

1977 " " (Ehrenberg); Petters, p.175, pl.1, fig.11,12.

non 1977 " striata (Ehrenberg); Petters, p.175, pl.1, fig.6.

non 1977 " " (Ehrenberg); Masters, pp.356-358, pl.3, figs.2,3.

1980 " " (Ehrenberg); Gawor-Biedowa, pp.33-34, pl.4, fig.7.

1981 " " (Ehrenberg); Frerichs & Dring, pl.1, figs.11,12.

Description: test free, slightly compressed, moderately and uniformly increasing in size; periphery becoming strongly lobate; cross-section bi-lobed and ovate, chambers arranged biserially, ten to twelve in number, globular to subglobular; sutures distinct and depressed; aperture a moderately high arch on the inner margin of the final chamber; wall calcareous and perforate, surface covered by quite strongly developed discontinuous striations.

Remarks: the taxonomic status of Heterohelix striata is uncertain and there is much confusion between this species and the closely related Heterohelix globulosa (Ehrenberg). Both were described by Ehrenberg from collections made from different stratigraphic horizons and from different geographical locations in Denmark, Poland, England, France and Egypt. Cushman (1938) studied the Ehrenberg collection in Berlin and concluded that H. globulosa can be differentiated from H. striata by its non striate surface. In an attempt to clarify the situation, Pessagno (1967, p.264) formally designated figure 2 alpha of Enrenberg (1840, pl.4) as the lectotype specimen and figure for H. striata and in doing so designated Kjølby Gaard, Jutland, Denmark as the type locality and the specimens figured by Berggren (1962) from this locality as topotypes. At the same time he also designated figure 5 beta (Ehrenberg 1840, pl.4) as the lectotype for H. globulosa, with Meudon, France as the type locality, and illustrated hypotypes from the

Taylor Formation, U.S.A. with extremely fine striations. Pessagno (1967) concluded that these two species may be representatives of the extreme morphological variants of a single species. However, Masters (1977) considered that the designation of lectotypes by Pessagno (1967) with a re-examination and re-illustration of Ehrenberg's material was "premature and pointless". He figures a specimen referred to H. striata which has much coarser and better developed costae and a higher aperture than the lectotype and is clearly not conspecific.

Frerichs & Dring (1981) figure both species from the Smoky Hill Shale, central Kansas, U.S.A. and clearly show H. striata to be larger and to have better developed costae than H. globulosa, and it is this concept that is followed in the present study. However, the exact relationship between the two species remains unclear and further study may eventually reveal them to be members of a single plexus.

Size: Height : 0.24mm
Width : 0.17mm

Distribution: this species 'tops' within the Late Maastrichtian (Zone F.I.1) of well 44/2-1, and within the Late Campanian (Zone F.I.3) of well 49/19-1. It is recorded rarely to commonly from these two well sections.

Family PLANOMALINIDAE Bolli, Loeblich & Tappan 1957
Genus GLOBIGERINELLOIDES Cushman & Ten Dam 1948
Type species Globigerinelloides algeriana Cushman & Ten Dam 1948

Globigerinelloides aspera (Ehrenberg 1854)

(Pl.9, fig.5a, b)

1854 Phanerostomum asperum Ehrenberg, p.23, pl.30, fig.26.

non 1854 Rotalia aspera Ehrenberg, p.24, pl.27, figs.57-58, pl,28, fig.42, pl.31, fig.44.

1891 " " Ehrenberg; Beissel, p.73, pl.14, figs.1-6.

1892 Globigerina aequilateralis (Brady); Chapman, p.517, pl.15, fig.14.

1936 Globigerinella aspera (Ehrenberg); Brotzen, p.170, pl.13, fig.2.

1957 Globigerina aspera (Ehrenberg); f.plana Hofker, pp.414-418, t.figs. 473-474.

p.1962 Planomalina (Globigerinelloides) messinae (Bronnimann); Berggren, pp.44-49, t.fig.7. (1-5), (non 6-8).

1962 " aspera (Ehrenberg); Barr, pp.561, 563, pl.69, fig.4.

1963 " (Globigerinelloides) aspera (Ehrenberg); van Hinte, p.97, pl.12, figs.2a, 3.

1964 Globigerinelloides aspera (Ehrenberg); Barr & Cordey, p.309.

1967 " " aspera (Ehrenberg); Bandy, p.12, t.fig.5 (8).

1967 " asperus (Ehrenberg); Pessagno, pp.274-275, pl.60, figs.4,5.

1967 " prairiehillensis Pessagno, pp.277-278, pl.60, figs.2, 3, pl.83, fig.1, pl.90, figs.1, 2, pl.97, figs.3,4.

1968 " aspera (Ehrenberg); Barr, pp.313-314, pl.37, fig.6.

pl1968 " messinae (Brönnimann); Sliter, p.99, pl.15, fig.3, (non fig.5).

1972 " aspera (Ehrenberg); Hanzlikova, p.98, pl.25, fig.1.

1973 " prairiehillensis Pessagno; Smith & Pessagno, p.39, pl.14, figs.1-4.

1977 " " Pessagno; Petters, pl.2, figs. 6,7.

non 1977 " volutus (White); Petters, pl.2, fig.8.

1977 " aspera (Ehrenberg); Villain, p.72, pl.13, figs. 4, 5.

1981 " prairiehillensis Pessagno; Frerichs & Dring pl.2, figs.3,4

1981 " aspera (Ehrenberg); Frerichs & Dring, pl.2, figs.1,2.

Description: test free, planispiral, bi-umbilicate with a lobate periphery; chambers inflated, globular and spherical arranged in two to three whorls, with six to seven in the last whorl and increasing moderately rapidly in size; sutures distinct, radial and depressed; aperture a low, broad, equatorial arch bordered above by a distinct lip, with relict apertures and apertural flaps moderately well developed.

Remarks: this species was originally described and figured by Ehrenberg (1854) from North America and the Isle of Rugen, Germany. However, Ehrenberg's failure to designate both a type locality and a type depository has resulted in much taxonomic confusion; it is unclear even as to whether Ehrenberg's species is planispiral or trochospiral in form (Pessagno 1967; Masters 1977). Rotalia aspera Ehrenberg (1854) cannot be assigned to Globigerinelloides with any certainty as only side views are shown in all of Ehrenberg's figures thus making it impossible to ascertain whether the specimens are planispiral and therefore assignable to Globigerinelloides, or trochospiral and therefore assignable to Hedbergella or Archaeoglobigerina.

To try to clarify the taxonomic confusion, Pessagno (1967) designated a lectotype of P. asperum with a planispiral test and an equatorial aperture, but did so without re-examining Ehrenberg's material or illustrating his newly designated lectotype. Pessagno also separated stratigraphically younger populations as G. prairiehillensis sp. nov. but failed to designate a type horizon; the value of Pessagno's work is thus questionable.

Size: Diameter : 0.31mm
Thickness : 0.21mm

Distribution: this species has its highest occurrence within the Late Maastrichtian (Zone F.I.1) of wells 44/2-1 and 49/19-1, and within the Early Maastrichtian (Zone F.I.2) of well 49/20-2. It is recorded only rarely throughout the studied sections.

Globigerinelloides multispina (Lalicker 1948)

(Pl. 9, fig.6a, b)

1948 Biglobigerinella multispina Lalicker, p.5, pl.92, figs.1-3.

1956(d) Globigerinella biforaminata Hofker, p.53, t.figs.2,5.

1956(b) Globigerina biforminata (Hofker); Hofker, p.76, pl.9, figs.68a-c, pl.10, figs.71a-c.

1957 Biglobigerinella multispina Lalicker; Bolli, Loeblich & Tappan, p.24, pl.1, figs.11-12b.

p.1962 Planomalina (Globigerinelloides) messinae (Brönnimann); Berggren, pp.44-46, pl.8, figs.4, 6, 8, non.fig. 7, t.fig.6, nos.2,5, non. nos. 1,3,4,6, t.fig.7, nos.6,7,8, non. nos.1-5.

1962 " multispina (Lalicker); Barr, p.563-564, pl.69, fig.5.

1963 Planomalina (Globigerinelloides) messinae biforminata (Hofker); van Hinte, p.102, pl.12, fig.4.

1964 Biglobigerinella multispina Lalicker; Loeblich & Tappan, p.C656, fig.526, nos.4,5.

1967 Globigerinelloides multispina (Lalicker); Pessagno, pp.276-277, pl.70, figs.1-2, pl.82, figs.10-11, pl.91, figs.1-2.

p1968 " messinae (Bronnimann); Sliter, p.99, pl.15, fig.5, non.fig.3.

1969 Biglobigerinella biforaminata (Hofker); Mello, p.95, pl.2, figs.3-5.

1969 Globigerinelloides multispina (Lalicker); Douglas, pp.161-162, pl.9, fig.6.

1973 " " (Lalicker); Smith & Pessagno, pp.38-39, pl.13, figs.1-11.

1977 " " (Lalicker); Rodriguez, p.378, pl.1, fig.5.

1981 " " (Lalicker); Frerichs & Dring, pl.2, figs.9,10.

Description: test free, planispiral, bi-umbilicate with a lobate periphery; chambers inflated, sub-circular to ovate with the final chamber flattened and broadly ovate and may be divided into paired chambers; chambers arranged in a semi-involute coil of two to three whorls, with five to six, moderately increasing chambers in the final whorl; sutures distinct, radial and depressed, straight to slightly curved; aperture a wide, highly arched bipartite opening at each side of the final chamber, bordered by a thickened well developed lip, forms with paired final chambers have a single aperture on each final chamber; wall perforate, surface finely papillate.

Remarks: this species was originally described by Lalicker (1948) and assigned to the genus Biglobigerinella Lalicker 1948. Lalicker erected this genus for forms occurring in a single population of planispiral forms that developed a biserial sequence with an initially uniserial sequence of chambers. However, forms which adopt a biserial habit have only been recorded from the Aptian (Loeblich & Tappan 1957) and from the Campanian and Maastrichtian (B. multispinata Lalicker 1948). As the Aptian biserial forms cannot be considered phylogenetically related to the Campanian-Maastrichtian forms (as they must have arisen independantly from a different species of Globigerinelloides), Biglobigerinelloides must be considered an artificial genus (Berggren 1962; Pessagno 1967; Smith & Pessagno 1973; Swiecicki 1980 (unpubl)). Therefore, biserial chambers and double apertures are considered specific and not generic characters.

Globigerinella biforaminata Hofker, a uniserial, bi-apertural form invariably occurs with B. multispina Lalicker a biserial, bi-apertural form and is considered a junior synonym, being an immature growth stage of the latter (Pessagno 1967; Smith & Pessagno 1973).

G. multispina probably arose from G. aspera stock in the middle Lower Campanian. This is substantiated by Swiecicki's (1980 (unpubl)) record of G. multispina as occurring throughout most of the Campanian and Maastrichtian but being absent from the basal Campanian.

Size: Diameter : 0.28mm
Thickness : 0.21mm

Distribution: this species is recorded rarely, 'topping' within the Late Maastrichtian (Zone F.I.1) of well 44/2-1, and in the mid Campanian (Zone F.I.4) of well 49/19-1. It is recorded only in the Late Turonian interval (Zone F.I.9) of well 49/20-2.

Globigerinelloides rowei (Barr 1962)

(Pl. 9, fig. 7a, b)

1962 Planomalina rowei Barr, p.564, pl.69, fig.2a, b.

Description: test free, planispiral, bi-umbilicate; chambers inflated, globular with the final chamber becoming slightly elongate, arranged in two whorls with four to five chambers in the final whorl increasing moderately rapidly in size as added; sutures distinct, radial, depressed and straight; aperture a low equatorial arch bordered above by a distinct lip which may develop into portici on the sides.

Remarks: the slight elongation of the final chamber gives this species a subquadrilateral outline, thereby making it morphologically distinct from other members of the genus. The range for this species given by Barr (1962) as occurring in the Micraster coranguinum Zone extending rarely into the Marsupites testudinaris Zone from his work on the Isle of Wight, is consistant with that recorded by Bailey (1978 (unpubl.)) for other parts of southern England.

Size: Diameter : 0.33mm
Thickness : 0.18mm

Distribution: rare specimens referable to this species are encountered in all the studied well sections, having their highest occurrence 'downhole' in the Late Santonian (Zone F.I.6) of well 49/20-2, in the Early Santonian (Zone F.I.7) of well 44/2-1, and in the Late Turonian (Zone F.I.9) of well 49/19-1.

Family HEDBERGELLIDAE Loeblich & Tappan 1961

Genus HEDBERGELLA Bronnimann & Brown 1958

Type species Anomalina lorneiana d'Orbigny var. trochoidea Gandolfi 1942

Hedbergella brittonensis Loeblich & Tappan 1961

(Pl.10, fig.1a, b. c.)

1934 Globigerina cretacea d'Orbigny; Morrow, p.198, pl.30, figs.7, 8, 10a,b.

1961 Hedbergella brittonensis Loeblich & Tappan, pp.274-275, pl.4, figs.1-8.

1961 " portsdownensis (Williams-Mitchell); Loeblich & Tappan, p.227, pl.5, fig.3.

1967 " brittonensis Loeblich & Tappan; Pessagno, p.282, pl.52, figs.9-12.

1967 " portsdownensis (Williams-Mitchell); Bandy, p.8, t.fig.3.

1969 " " (Williams-Mitchell); Douglas & Rankin, pp.194-196, fig.7a-f.

1970 " " (Williams-Mitchell); Eicher & Worstell, p.304, pl.10, figs.1a-c, 2a-b.

1972 " brittonensis Loeblich & Tappan; Gawor-Biedowa, pp.67-68, pl.8, figs. 1a-c, 2a-c.

1977 " " Loeblich & Tappan; Carter & Hart, pp.31-32, pl,4, figs.13-15.

1979 Whiteinella brittonensis (Loeblich & Tappan); Robaszynski & Caron (part 1), pp.175-180, pl.37, figs.1a-c, 2a-c, pl.38, figs.1a-c, 2a-c.

1981 Hedbergella brittonensis Loeblich & Tappan; Hart et al. in Jenkins & Murray, p.202, pl.7.15, figs.7-9.

1982 " " Loeblich & Tappan; Gawor-Biedowa, pl.9, figs.3-5.

1982 " " Loeblich & Tappan; Weiss, pp.85-86, pl.1, figs.9-11.

Description: test free, high asymmetrical trochospire of two to two and a half whorls; chambers inflated and globular with a pustulose surface, gradually increasing in size as added with five and a half to seven in the final whorl; sutures distinct, radial and depressed; primary aperture umbilical-extraumbilical, bordered by a lip, umbilicus narrow.

Remarks: this species was originally described by Loeblich & Tappan (1961) from the Cenomanian of Germany. The type figures clearly show a high, asymmetrical trochospire to be characteristic.

This is a long-ranging species and probably evolved from the earlier Hedbergella delrioensis (Carsey 1926) stock - an idea supported by the presence of numerous transitional forms between the two species (Pessagno 1967; Bailey 1978 (unpublished)).

Much taxonomic confusion surrounds H. brittonensis and its relationship to H. portsdownensis (Williams-Mitchell 1948). The type figures of H. portsdownensis clearly show this species to be a high-spired form, a concept which is followed by Loeblich & Tappan (1961) in their illustrations of H. portsdownensis, contrary to their claim that the species has a low spire. After examining the holotype of H. portsdownensis, Hart (1970) concluded that the original description of the species was incorrect; the holotype does not possess an elevated spire and probably represents an early transitional form from H. delrioensis. Thus, later publications recording high-spired forms of H. portsdownensis are here included in the synonymy of H. brittonensis.

The separation of H. brittonensis from the lower spired H. delrioensis (Carsey) and the higher spired Whiteinella paradubia (Sigal 1952) is problematic; in any one population there may be a full range from the lower spired H. delrioensis, to the high spired H. brittonensis to the very high spired W. paradubia (Carter & Hart 1977). This is further complicated in the Late Cenomanian and in the Turonian when the aperture becomes umbilical in position thus changing the generic position of brittonensis from a Hedbergella to a Whiteinella (Robaszynski & Caron 1979; Hart et al. 1981).

A detailed account of the evolutionary relationships of H. brittonensis can be found in Carter & Hart 1977.

Size: Diameter : 0.32mm
Thickness : 0.27mm

Distribution: this species has its highest occurrence within the Early Santonian (Zone F.I.6) of well 49/20-2, and within the Coniacian (Zone F.I.8) of wells 44/2-1 and 49/19-1. It is recorded moderately commonly to abundantly in certain intervals of the studied wells, notably the Early Turonian in well 49/19-1 and the Turonian of well 49/20-2.

Hedbergella delrioensis (Carsey 1926)
(Pl.10, fig.2a, b, c)

1926 Globigerina cretacea d'Orbigny var. delrioensis Carsey, p.43.
?1940 " " d'Orbigny; Tappan, pp.121-122, pl.19, fig.11.
?1943 " " d'Orbigny; Tappan, p.512, pl.82, figs.16-17.
1952 " gautierensis Brönniman, p.11, pl.1, figs.1-3, t.fig.2a-c.
1954 " delrioensis Carsey; Frizzell, p.127, pl.20, fig.1.

1959 Praeglobotruncana gautierensis (Brönniman); Bolli, p.265, pl.21, figs.3-6.

1959 " (Hedbergella) delrioensis (Carsey); Banner & Blow, p.8.

p1960 " gautierensis (Brönniman); Jones, p.102, pl.15, figs.1a-c, 2a-c, ?3, ?4, 5, ?6, 7a-c, 8, 9a-c, t.fig.1.

1962 Hedbergella delrioensis (Carsey); Takayanagi & Iwamoto, p.190, pl.28, figs.10-12.

1966 " " (Carsey); Butt, pp.173-174, pl.2, figs.1-8.

1967 " " (Carsey); Pessagno, pp.282-283, pl.48, figs.1-5.

1970 " " (Carsey); Eicher & Worstell, p.302, pl.9, figs.10, 11a-b.

1974 " " (Carsey); Longoria; pp.54-55, pl.10, figs.1-12, pl.13, figs.3-5; 15-17; 18, pl.26, figs.10-11.

1977 " " (Carsey); Carter & Hart, p.35, pl.4, figs.1-2.

1979 " " (Carsey); Robaszynski & Caron (part 1), pp.123-128, pl.22, figs.1a-c, 2a-c, pl.23, figs.1a-c, 2a-c, 3a-c.

1981 " " (Carsey); Hart et al. in Jenkins & Murray, p.202, pl.7.15, figs.10-12.

1982 " " (Carsey); Weiss, pp.86-87, pl.1, figs.1-3.

Description: test free, biconvex and slightly asymmetrical; low to moderate trochospire with a lobate periphery; chambers inflated and globular with a pustulose surface, except for the last one which is less ornamented and may be smooth, increasing rapidly in size as added with four to six (normally five) in the final whorl; sutures distinct,

radial and depressed; primary aperture a simple interiomarginal extraumbilical-umbilical arch, commonly bordered by a lip, umbilicus very narrow.

Remarks: this species was originally described by Carsey (1926) from the Cretaceous of Texas (Grayson Formation, Travis County) but no type figure was included. As the depository of the type specimens is unknown, the establishment of a neotype was necessary (Longoria 1974). The neotype clearly shows the typical moderate spire and five chambers per whorl.

Previous authors have generally assigned moderate to low spired forms occurring in the Albian to Turonian interval to this species. A complete range from almost flat (H. planispira (Tappan 1940)) to very high spired forms (H. brittonensis Loeblich and Tappan 1961) is seen within the genus Hedbergella and separate specific names have been proposed for extreme forms and their intermediates. Carter & Hart (1977) concluded that the variation is continuous and not naturally subdivisible but for convenience retain the end members of the plexus as separate species.

Size: Diameter : 0.31mm
Thickness : 0.21mm

Distribution: common to abundant specimens referable to this species are recorded from all the studied well sections, 'topping' within the Late Turonian (Zone F.I.9) of wells 49/19-1 and 49/20-2, and within the Late-Middle Cenomanian (Zone F.I.11) of well 44/2-1.

Hedbergella planispira (Tappan 1940)

(Pl.10, fig.3a, b, c)

1940 Globigerina planispira Tappan, p.12, pl.19, fig.12.

1948 " almadenensis Cushman & Todd, p.95, pl.16, figs.18,19.

1949 " globigerinelloides Subbotina, p.32, pl.2, figs.11-16.

1954 Globorotalia ? youngi Fox, p.119, pl.26, figs.15-18.

1956 Hedbergina seminolensis (Harlton); Brönnimann & Brown, p.529, pl.20, figs.4-6.

1957 Praeglobotruncana planispira (Tappan); Bolli, Loeblich & Tappan, p.40, pl.9, fig.3.

1959 " modesta Bolli, p.267, pl.22, fig.2.

1959 " planispira (Tappan); Bolli, p.267, pl.22, figs.3-4.

1961 Hedbergella planispira (Tappan); Loeblich & Tappan, pp.276-277, pl.5, figs.4-11.

1967 " " (Tappan); Pessagno, pp.283-284, pl.51, fig.1, pl.53, figs.1-4.

1969 " " (Tappan); Douglas, p.168, pl.5, fig.1.

1972 " " (Tappan); Gawor-Biedowa, pp.70-71, pl.5, fig.8a-c.

1977 " " (Tappan); Carter & Hart, pp.36-37, pl.4, figs.4-6.

1979 " " (Tappan); Robaszynski & Caron (part 1), pp.139-144, pl.27, figs.1a-c, 2a-c, 3a-c, pl.28, figs.1a-c, 2a-c, 3a-c, 4a-c.

1981 " " (Tappan);Hart et al. in Jenkins & Murray, p.204, pl.7.16, figs.4,5.

1982 " (Tappan); Gawor-Biedowa, pl.8, figs.4-6.

1982 " " (Tappan); Weiss, p.87, pl.1, fig.12.

Description: test free, small and almost planispiral with a flat spiral side and a lobate periphery; chambers inflated, globular and smooth, arranged in two to two and a half whorls, with six to seven in the last whorl and gradually increasing in size as added; sutures distinct, radial and depressed; primary aperture a simple interiomarginal extraumbilical-umbilical arch, bordered by a narrow lip, umbilicus large.

Remarks: this species was originally described by Tappan from the Grayson Formation of north Texas (1940).

Hedbergella planispira can be distinguished from other species of Hedbergella by its small size and very low trochospire giving the test an almost planispiral appearance.

Size: Diameter : 0.26mm
Thickness : 0.13mm

Distribution: this species was recorded rarely to commonly in the studied well sections, 'topping' within the Early Turonian (Zone F.I.10) of 49/19-1, and within the Late-Middle Cenomanian (Zone F.I.11) of wells 44/2-1 and 49/20-2.

Genus WHITEINELLA Pessagno 1967
Type species Whiteinella archeocretacea Pessagno 1967

Whiteinella aprica (Loeblich & Tappan 1961)
(Pl.10,fig.4a,b,c)

1955 Globotruncana (Rotundina) californica (Cushman & Todd); Küpper, p.116, pl.18, fig.7.
1961 Ticinella aprica Loeblich & Tappan, p.292, pl.4, figs.14-16.
1979 Whiteinella aprica (Loeblich & Tappan); Robaszynski & Caron (part

2), pp.157-160, pl.32, figs.1a,b,c, 2a,b,c.

1981 " " (Loeblich & Tappan);Hart et al. in Jenkins & Murray, p.222, pl.7.25, figs.10-12.

1982 " " (Loeblich & Tappan);Weiss, p.97, pl.2, figs.4-6.

Description: test free, low trochospire of two to two and a half whorls, biconvex to concavo-convex; equatorial periphery lobate; chambers globose with a pustulose surface, slowly increasing in size as added, with five to seven in the final whorl (commonly six); sutures distinct, radial and depressed; primary aperture extraumbilical-umbilical, bordered by a porticus, umbilicus shallow and wide.

Remarks: this species was originally described from the Arcadia Park shale (Turonian), Dallas, USA (Loeblich & Tappan 1961), and can be identified on the basis of its low spire. It can be distinguished from Hedbergella brittonensis Loeblich & Tappan 1961, by the lower spire, the wide umbilicus and flaps in the umbilicus.

Size: Diameter : 0.31mm

Thickness : 0.21mm

Distribution: in the present study, this species first appears 'downhole' in the Late Turonian (Zone F.I.9) of all the studied well sections, and is recorded rarely to abundantly in the recovered microfaunas.

Whiteinella baltica Douglas & Rankin 1969

(Pl. 11, fig.1a, b. c.)

1969 Whiteinella baltica Douglas & Rankin, p. 197, fig.9A-I.

1969 Hedbergella bornholmensis Douglas & Rankin, p.193, fig.6A-I.

1969 Rugoglobigerina? alpina Porthault, p.38, pl.2, figs.1a-c, 2a-c, 3a-c.

1979 " baltica Douglas & Rankin; Robaszynski & Caron (Part 2), pp.169-174, pl.35, figs.1a-c, 2a-c, 3, 4a-b, 5, pl.36, figs.1a-c, 2a-c.

1981 " " Douglas & Rankin; Hart et al. in Jenkins & Murray, p.222, pl.7.25, figs.13-15.

1982 " " Douglas & Rankin; Weiss, p.98, pl.2, figs.7-9.

Description: test free, low trochospire, almost bilaterally symmetrical; equatorial periphery lobate; chambers inflated globose on both sides, with four to five (commonly four) in the final whorl; sutures depressed and radial on both sides; primary aperture umbilical to slightly extraumbilical; umbilicus narrow; surface granulose.

Remarks: this species was originally described by Douglas & Rankin in September 1969 from the Late Cretaceous of Bornholm, Denmark. The arrangement of the chambers and the umbilical position of the primary aperture is distinctive. After studying topotype material of Hedbergella bornholmensis Douglas & Rankin 1969, described at the same time as W. baltica, Bailey (1978 (unpubl.)) concluded that the differences recognised by the authors were minor, and H. bornholmensis merely represented a growth stage of W. baltica.

Also in 1969, Porthault described and illustrated a species he called Rugoglobigerina? alpina for the first time. However, Robaszynski & Caron (1979) consider W. alpina and H. bornholmensis to be within the variation of W. baltica. As the month of publication of W. alpina is not known, W. baltica must have priority.

Size: Diameter : 0.25mm

Thickness : 0.16mm

Distribution: this species has its highest occurrence in the Late Santonian (Zone F.I.6) of wells 49/19-1 and 49/20-2, and in the Early Santonian (zone F.I.7) of well 44/2-1. It is recorded rarely to moderately abundantly throughout the studied well sections.

Family GLOBOTRUNCANIDAE Brotzen 1942

Note: as many of the genera within this family have been incorporated into the literature since the proposed classification by Loeblich & Tappan (1964, Treatise; amended 1974), subdivision below family level has not been attempted in this section.

Genus DICARINELLA Porthault 1970

Type species Globotruncana indica Jaboc & Sastry 1950

Dicarinella algeriana (Caron 1966)

(Pl.11, fig.2a, b, c)

1936 Globotruncana appenninica - Globotruncana linnei Renz, p.34, pl.6, figs.18-20, table 8, fig.2.

1945 " renzi Thalmann, p.405.

1960(a) Praeglobotruncana renzi (Thalmann); Klaus, pp.795-796, pl.6, fig.4a-c.

1961 " " (Thalmann); Malapris & Rat, pp.90-91, pl,2, fig.5a-c, t.fig.6.

1966 " " (Thalmann); Eicher, pp.28-29, pl.6, fig.9.

1966 " algeriana Caron, pp.74-75.

1969 " " Caron; Neagu, p.142, pl.17, figs.8-15, pl.20, figs.4-6, pl.22, figs.7-8, pl.23, figs.1-2.

1977 " " Caron; Carter & Hart, p.38, pl.3, figs.1-3.

1979 Dicarinella algeriana Caron; Robaszynski & Caron (part 2), pp.57-60, pl.50, figs.1a-d, 2a-d.

Description: test free, biconvex with a low to moderately high trochospire; periphery truncate with two imperforate keels separated by a narrow imperforate band; the keels become progressively less distinct in the last chambers and maybe reduced to one, or absent; chambers on umbilical side triangular to trapezoidal in shape and slightly inflated, and petoloid and flattened on the spiral side, moderately increasing in size as added with five to seven in the final whorl; surface pustulose; sutures radial and depressed on umbilical side, curved on the spiral side; primary aperture extraumbilical-umbilical, bordered by a well developed lip, umbilicus narrow.

Remarks: this species was first described by Caron and figured from the Upper Cretaceous of Switzerland (1966). The designated holotype is the specimen figured by Reichel in 1949 from the Turonian of Algeria (Pl. XVI, fig. 8 and Pl. XVII, fig. 8) as Globotruncana (Globotruncana) aff. renzi Thalmann-Gandolfi. This species is very important phylogenetically because it is the earliest Upper Cretaceous planktonic species to have two keels. Thus, Caron justifiably recognised it as a separate form distinct from the stratigraphically younger G. renzi Gandolfi group.

Dicarinella algeriana is similar to D. hagni (Scheibnerova 1962) the main difference being that D. hagni is more elevated dorsally and less convex ventrally. Intermediate forms between the two species were noted by Carter & Hart (1977) in the Plenus Marl.

D. algeriana differs from Praeglobotruncana stephani (Gandolfi 1942) in having two keels separated by a narrow, imperforate, peripheral band.

Size: Diameter : 0.36mm

Thickness : 0.32mm

Distribution: this species 'tops' within the Early Turonian (Zone F.I.10) of all the studied well sections and is recorded in moderate abundance to abundantly throughout.

Dicarinella canaliculata (Reuss 1854)

(Pl. 11, fig. 3a,b,c)

1854 Rosalina canaliculata Reuss, p. 70, pl. 26, fig. 4 a,b.

1956 Globotruncana marginata (Reuss); Jirova, pl. 1, fig. 1a-c.

1960 " canaliculata (Reuss); Trujillo, p. 341, pl. 50, figs. 5-8.

1967 Marginotruncana " (Reuss); Pessagno, pp. 302-4, pl. 74, figs. 5-8.

1970 Praeglobotruncana (Dicarinella) canaliculata (Reuss); Porthault, in Donze et al., p. 72, pl. 13, fig. 24.

1979 Dicarinella canaliculata (Reuss); Robaszynski & Caron, (part 2), pp. 67-70, pl. 53, figs. 1 a-c, 2 a-c, 3 a-c.

Description: test free, flattened trochospire; periphery truncate with two widely spaced keels separated by an imperforate band, the keels are parallel and continue to the last-formed chamber; chambers on umbilical side trapezoidal in shape and petaloid, flat to slightly inflated on the spiral side, increasing gradually in size as added with five to seven (commonly six) in the final whorl; surface pustulose; sutures initially radial and depressed but may become curved forwards on the umbilical side, raised and curved on the spiral side; primary aperture extraumbilical-umbilical and can be covered by portici, umbilicus narrow.

Remarks: this species was originally described by Reuss from the lower part of the Gosau Beds of Edelbachgraben, Austria (1854). Reuss's original description of the species included figures of the spiral and umbilical views only which has resulted in this species frequently being mis-identified and confused with a number of other double-keeled Upper Cretaceous species. It has often been confused with Marginotruncana marginata (Reuss 1854) but can be distinguished by the thicker and more widely spaced keels and an almost flat trochospire. Both species were described by Reuss in 1854 from the same section in Austria. The neotype selected by Jirova (1956) for M. marginata has two quite thick, widely spaced keels and is thus more representative of D. canaliculata.

The depository of Reuss's type specimens for D. canaliculata is unknown. To try to clarify the taxonomic situation Pessagno (1967) selected a neotype following Reuss's original description. Thus the neotype has a wide double keel, petaloid to crecent shaped chambers spirally, trapezoidal in shape umbilically and a small umbilicus.

This species differs from M. pseudolinneiana Pessagno 1967 in having radial sutures umbilically, although separation maybe difficult as intermediate forms exisist between the two (Robaszynski & Caron 1979).

Size: Diameter : 0.42mm
Thickness : 0.21mm

Distribution: 'topping' within the Early Santonian (Zone F.I.7) of wells 49/19-1 and 49/20-2, and at the top of the Coniacian (Zone F.I.8) of well 44/2-1, this species is recorded rarely to abundantly in all the studied well sections.

Dicarinella concavata (Brotzen 1934)

(Pl. 11, fig. 4a,b,c,)

1934 Rotalia concavata Brotzen, p. 66, pl. 3, fig. 6.

?1941 Globotruncana linnei (d'Orbigny) subsp. pendens Volger, p. 287, pl.24, figs. 4-6, non figs. 1-3,7.

1955 " (Globotruncana) ventricosa ventricosa White; Dalbiez, p. 168, t. figs. 7a-d.

1955 " " ventricosa carinata Dalbiez, pp. 168-9, t. figs. 8a-c.

1957 " concavata (Brotzen); Bolli et al., p.57, pl. 13, fig. 3 a-c.

non1962 " " (Brotzen); Herm, pp. 70-71, pl. 5, fig.4.

1967 Marginotruncana " (Brotzen); Pessagno, pp. 304-5, pl. 58, figs. 1-9, pl. 95, figs. 6,7, pl. 99, figs. 1-3.

1970 Praeglobotruncana (Dicarinella) concavata (Brotzen); Porthault, in Donze et al., p. 73, pl.10, figs. 7,8, pl. 13, fig. 25.

1971 Globotruncana concavata (Brotzen); Postuma, pp. 26-27, 7 figs.

1979 Dicarinella " (Brotzen); Robaszynski & Caron (part 2), pp. 71-78, pl. 54, figs. 1a-c, 2a-c, pl. 55, fig. 1a-c.

1980 " " (Brotzen); Gawor-Biedowa, pp. 36-37, pl. 6, figs. 4-7.

1981 " " (Brotzen); Hart et al. in Jenkins & Murray, pp. 186-187, pl. 7.7, figs. 9,10

Description: test free, asymmetrical low trochospire, plano-convex to concavo-convex; periphery angular with two closely spaced keels separated by a thin imperforate band; chambers on the umbilical side strongly inflated in the later stages with a pustulose surface, the pustules are particularly concentrated around the umbilicus, petaloid and flattened on the spiral side, increasing rapidly in size as added with five to six in the final whorl; sutures radial and depressed on the umbilical side, oblique and slightly elevated on the spiral side; primary aperture an interiomarginal low arch, umbilical to slightly extra-umbilical, umbilicus deep.

Remarks: in 1934 Brotzen erected and figured the species Rotalia concavata clearly showing a plano-convex form with a double keel. This species has since been confused with Globotruncana ventricosa (White), and many workers (eg. Bolli 1957, p.57) have suggested the two are phylogenetically related. Although the two species may appear similar superficially, detailed study has shown them to be unrelated at both family and species level (Pessagno 1967, p. 304).

Barr (1962) records the range of D. concavata as extending through most of the Micraster Zones of Culver Cliff. Bailey (1978 (unpubl.)) has recorded this species throughout the early part of the U. socialis Zone from Kent, Essex and Wiltshire. This is in agreement with the range recorded by van Hinte (1976). The occurrance of this species is only sporadic in the U.K. but is of great stratigraphic value (Bailey 1978 (unpubl.); Hart et al. 1981).

Size: Diameter : 0.39 mm
Thickness : 0.19 mm

Distribution: very rare specimens referable to this species were first recorded 'downhole' within the Coniacian (Zone F.I. 8) of wells 44/2-1 and 49/19-1, and from only one sample within the Early Turonian (Zone F.I. 10) of well 49/20-2. This species was recorded only sporadically and rarely in the studied well sections.

Dicarinella hagni (Scheibnerová 1962)

(Pl. 12, fig. 1a,b,c)

1962 Praeglobotruncana hagni Scheibnerová, pp. 219, 225-6, t. fig. 6a-c.

1966 " " Scheibnerová; Caron, p. 76, pl. 2, fig. 6a-c.

1966 " sp. cf P. hagni Scheibnerová; Butt, p. 17, pl. 3, figs. 1,?2, ?3, ?4.

1977 " hagni Scheibnerová; Carter & Hart, p. 39, pl. 3, figs. 10-12.

1979 Dicarinella hagni Scheibnerová; Robaszynski & Caron (part 2), pp 79-86, pl. 56, figs. 1a-c, 2a-c, pl. 57, figs. 1a-c, 2a-c.

?1980 " radwanskae Gawor-Biedowa, pp. 37-38, pl.6, figs. 8-10.

1981 " hagni Scheibnerová; Hart et al., in Jenkins & Murray, p.186, pl. 7.7, figs. 11,12.

1982 " " Scheibnerová; Robaszynski et al., pl. 9, fig. 3a-b, pl. 13, fig. 4a-c.

1982 Praeglobotruncana hagni Scheibnerová; Weiss, pp. 89-90, pl. 4, figs. 1-3.

Description: test free, asymmetric biconvex to plano-convex low trochospire; periphery with two closely spaced keels that maybe absent in the last or penultimate chamber; chambers on umbilical side triangular to trapezoidal in shape, inflated to globular, initially pustulose, becoming smooth in the last two chambers and petaloid, flat to slightly convex on the spiral side, gradually increasing in size as added with five to eight, commonly six in the final whorl; sutures radial and depressed on umbilical side, rasied, oblique and curved forwards on the spiral side; primary aperture extraumbilical-umbilical, umbilicus narrow.

Remarks: this species has a confused taxonomic history (see Robaszynski & Caron 1979). In 1966, Marianos & Zingula described and figured a species - Globotruncana roddai, from the Turonian of California. The type figures show very clearly a strong morphological similarity with D. hagni. In 1969, Douglas also described this species from California and suggested that it was synonymous with D. hagni; this opinion is also shared by Carter & Hart (1977) and Robaszynski and Caron (1979).

D. hagni appears to be characterisitic of the boreal realm (Robaszynski & Caron 1979; Hart et al. 1981).

Size: Diameter : 0.45mm
Thickness : 0.19 mm

Distribution: this species first appears at the top of the Early Turonian (Zone F.I. 10) in all the studied well sections and is recorded rarely to moderately abundantly throughout.

Genus PRAEGLOBOTRUNCANA Bermudez 1952

Type species Globorotalia delrioensis Plummer 1931

Praeglobotruncana delrioensis (Plummer 1931)

(Pl. 12, fig. 2a,b,c)

1931 Globorotalia delrioensis Plummer, p.199, pl.13, fig.2a-c.

non 1940 " " Plummer; Tappan, p.123, pl.19, fig.14.

1946 " marginaculeata Loeblich & Tappan, p.257, pl. 37, figs. 19-21, t. fig. 4a.

non 1946 " delrioensis Plummer; Loeblich & Tappan, p.257, t.fig.46.

1950 Globotruncana stephani Gandolfi: Mornod, p.587, pl.15, figs.9a-r, 10, 17, t.fig.10, 1-3.

1952 Praeglobotruncana delrioensis (Plummer); Bermudez, p.52, pl.7, fig.1.

1954 Globotruncana stephani Gandolfi; Hagn & Zeil, p.33, pl.2, fig.7, pl.5, figs.7,8.

1956 Praeglobotruncana delrioensis (Plummer); Brönnimann & Brown, p.53, pl.21, figs.8-10, pl.24, figs.?16,17, t.figs.9,13a,b,d, ?15c-f, (non t.figs.16c-e).

non 1957 " " (Plummer); Zeigler, p.199.

1959 " (Praeglobotruncana) sp. cf. stephani (Gandolfi); Banner & Blow, pl.3, fig.4.

1960a " delrioensis (Plummer); Klaus, pp.793-4, pl.6, fig.1a-c.

1960b " " (Plummer); Klaus, pp.300-301, t.fig.1a.

1961 " " (Plummer); Loeblich & Tappan, pp.280-284, pl.6, figs. 9-12.

1967 ——— " ——— (Plummer); Pessagno, pp.286-287, pl.52, figs.3-5, pl.100, fig.7.

1977 ——— " ——— (Plummer); Carter & Hart, pp.38-39, pl.4, figs.22-24.

1979 ——— " ——— (Plummer); Robaszynski & Caron (part 2), pp.29-32, pl.43, fig.1a-c, fig.2a-c.

1981 ——— " ——— (Plummer); Hart et al. in Jenkins & Murray, p.214, pl.7.21, figs.7,8.

1982 ——— " ——— (Plummer); Weiss, p.89.

Description: test free, low trochosphere of two to two and a half whorls, biconvex and slightly compressed; margins of the chambers marked by an accumulation of pustules; chambers on umbilical side triangular in shape, and petaloid and gently inflated on spiral side, moderately increasing in size as added with five to six in the final whorl; sutures distinct and depressed on umbilical side, curved and slightly thickened on spiral side; primary aperture extraumbilical-umbilical, bordered by a narrow lip; umbilicus narrow.

Remarks: this species was first described by Plummer from the Lower Cretaceous of the Del Rio Formation, Austin, Travis County, Texas (1931). The type figures are small but clearly show the species to be compressed with a single keel. The species was previously mentioned as occuring in the Upper Cretaceous of the Del Rio Formation (Univ. Texas Bull. 2612, p.45), but was identified with Globotruncana rosetta (Carsey) (=G. arca (Cushman)). Plummer concluded that in spite of the similarity in the arrangement of the chambers in the two forms, the definite single keel, the more compressed test and the apertural characteristics make this form (P. delrioensis) generically and specifically different.

There has been much confusion between the present species and Praeglobotruncana stephani (Gandolfi) with which it was regarded as synonymous by Brönniman & Brown (1956), Zeigler (1957) and Banner & Blow (1959). P. delrioensis can be distinguished from P. stephani by the lower trochospire and the less developed marginal band of pustules, but these two forms are very closely related. Loeblich & Tappan (1961) stated the two species were quite distinct, but that P. delrioensis displays a wide range of variability. In adopting this wide concept, they included P. marginaculeata (Loeblich & Tappan) within its synonymy. However, Carter & Hart (1977) agreed only that the type specimens were distinct, and therefore there is justification for the retention of the specific names, but in studies where complete sequences of strata are sampled at close, regular intervals a complete gradation is seen between the two, and P. delrioensis evolves imperceptibly into P. stephani during the mid-Cenomanian thus making accurate differentiation impossible. It is clear, therefore, that the two species belong in a single evolutionary plexus beginning with P. delrioensis; the same conclusion had previously been reached by Klaus (1960b) from his statistical studies in which he identified just one lineage for P. delrioensis, P. marginaculeata and P. stephani.

Size: Diameter : 0.255 mm
Thickness : 0.155 mm

Distribution: this species is first recorded 'downhole' at the top of the Middle-Early Cenomanian (Zone F.I.12) of all the studied well sections and is recorded rarely to abundantly throughout.

Praeglobotruncana helvetica (Bolli 1945)

(Pl.12, figs.3a, b, c)

1945 Globotruncana helvetica Bolli, p.226, pl.9, figs.6-8, t.fig. 1 (9-12).

1960 ____" ____" Bolli; Trujillo, pp.341-342, pl.50, fig.2a-c.

1966 Praeglobotruncana stephani (Gandolfi); Douglas & Sliter, p.107, pl.4, fig.1a-c.

1966 ____" ?helvetica (Bolli); Caron, p.74, pl.3, fig.2a-c.

1969 ____" ____" (Bolli); Douglas, pp.169-170, pl.4, figs.4,5.

1969 ____" ____" (Bolli); Scheibnerova, pp.,58-59, pl.8, fig.2a-c.

1972 ____" ____" (Bolli); Gawor-Biedowa, pp.73-74, pl.8, fig.4a-c.

1979 ____" ____" (Bolli); Robaszynski & Caron (part 2), pp.39-42, pl.46, fig.1a-c, 2a-c.

1981 ____" ____" (Bolli); Hart et al. in Jenkins & Murray, p.214, pl.7.21, figs.9,10.

1982 Helvetoglobotruncana helvetica (Bolli); Robaszynski et al, pl.9, fig.5a-c, pl.13, fig.2a-c, 3a-c.

1982 ____" ____" (Bolli); Gawor-Biedowa, pl.11, figs.5-7.

1982 ____" ____" (Bolli); Weiss, p.90, pl.3, figs.11-13.

Description: test free, plano-convex and strongly asymmetrical, periphery marked by a single keel forming an edge to the flat spiral surface; two to two and a half whorls with four to five chambers in the final whorl; chambers on umbilical side inflated and rugose and petaloid with a flat surface on the spiral side, moderately increasing in size as added; sutures distinct, radial and depressed on umbilical side, raised and curved on spiral side; primary aperture extraumbilical-umbilical, bordered by a well-developed lip, umbilicus wide.

Remarks: this species was originally described from the basal Turonian of Eastern Switzerland (1945). The type figures are mostly of the species in cross-section but clearly show the single keel forming the edge to a flat spiral surface.

It is difficult to assign this species to a genus as it has a few characteristics of several genera, e.g. Globotruncana, Praeglobotruncana and Whiteinella. Reiss (1957) erected the new genus Helvetoglobotruncana after working on material in section, with the present species as type; this genus has since been regarded as a junior synonym of Globotruncana Cushman (Loeblich & Tappan 1964).

Douglas assigned the present species to the genus Praeglobotruncana because of the absence of accessory apertures and tegillae. This was also followed by Bandy (1967) based on his assumption that it originated from P. delrioeinsis (Plummer) stock by the development of a flattened surface on the spiral side with a keel at the periphery; the presence of a keel excludes it from the genus Whiteinella Pessagno. Robaszynski & Caron (1979) also assign this species to Praeglobotruncana on the basis of the external characters and this is followed in the present study.

Size: Diameter : 0.23mm
Thickness : 0.15mm

Distribution: specimens referable to this species first appear 'downhole' at the base of the Late Turonian (Zone F.I.9) in well 49/20-2 and in the Early Turonian (Zone F.I.10) of wells 44/2-1 and 49/19-1. It is recorded rarely to moderately abundantly in the recovered microfaunas.

Praeglobotruncana stephani (Gandolfi 1942)

(Pl. 12, fig. 4a,b,c)

1942 Globotruncana stephani Gandolfi, p.130, pl.3, figs.4,5, pl.4, figs.36, 37, 41-45, pl.6, figs.4, 6, pl.9, figs.5, 8, pl.13, fig.5,pl.14, fig.2.

1942 " appeninica var. beta Gandolfi, p.119, t.fig.41,(2a,b).

1948 " californica Cushman & Todd, p.96, pl.16, figs.22,23

1950 " (Globotruncana) stephani Gandolfi; Reichel, p.609, pl.16, fig.6, pl.17, fig.6.

1950 " stephani Gandolfi var. turbinata Reichel, p.609.

1953 Rotundina " (Gandolfi); Subbotina, p.165, pl.2, figs.5-7, pl.3, figs.1-3.

1954 Globotruncana " Gandolfi; Ayala-Castanares, p.412, pl.11, fig.2.

1954 " " Gandolfi var. turbinata Reichel; Ayala-Castanares, p.412, pl.11, fig.3.

1955 " (Rotundina) aumalensis (Sigal); Kupper, p.116, pl.18, fig.5.

1955 " (") stephani Gandolfi; Kupper, p.116, pl.18, fig.6.

1956 " (Praeglobotruncana) stephani Gandolfi var. turbinata Reichel; Kupper, p.43, pl.8, fig.1a-c.

1956 " (") renzi (Thalmann & Gandolfi) subsp. primitiva Kupper, p.43, pl.8, fig.2a-c.

1956 Praeglobotruncan delrioensis var. turbinata (Reichel); Bronnimann & Brown, p.532, t.fig.16c-e.

1959 Globotruncana kupperi Thalmann, p.130.

1959 Praeglobotruncana (Praeglobotruncana) stephani (Gandolfi); Banner & Blow, p.3, t.fig.1a.

1960a ____" ____ stephani (Gandolfi); Klaus, p.794, pl.6, fig.2a-c.

1960a ____" ____ " ____ var. turbinata (Reichel); Klaus, p.795, pl.6, fig.3a-c.

1964 ____" ____ " ____ (Gandolfi); Loeblich & Tappan, p.C659, fig.527, 3a-c.

1967 ____" ____ " ____ (Gandolfi); Pessagno, p.287, pl.50, figs.9-11.

1969 ____" ____ " ____ (Gandolfi); Douglas, p.173, pl.2, fig.1.

1972 ____" ____ " ____ (Gandolfi); Gawor-Biedowa, pp.76-78, pl.8, fig.1a-c.

1977 ____" ____ " ____ (Gandolfi); Carter & Hart, p.40, pl.4, figs. 16-21.

1979 ____" ____ " ____ (Gandolfi); Robaszynski & Caron (part 2), pp.47-50, pl.48, figs.1a-c, 2a-b, 3a-b.

1980 ____" ____ " ____ (Gandolfi); Hart et al., in Jenkins & Murray, p.214, pl.7.21, figs. 11-13.

1982 ____" ____ " ____ stephani (Gandolfi); Gawor-Biedowa, pl.10, figs.3-5.

1982 ____" ____ " ____ (Gandolfi); Weiss, p.92, pl.2, figs.10-12

Description: test free, moderate to high trochospire of two to two and a half whorls with a beaded peripheral margin; chambers on umbilical side triangular to trapezoidal and slightly inflated and petaloid, flat to gently inflated on spiral side, moderately increasing in size as added with five to seven in the final whorl; sutures radial and depressed on the umbilical side, curved and distinctly beaded on the spiral side; primary aperture extraumbilical-umbilical, bordered by a well-developed lip, umbilicus narrow.

Remarks: this species was originally described from the Cenomanian, Canton Ticino, southeastern Switzerland. The type figures include both external and cross-sectional views and clearly show a single-keeled, moderate to high spired form with beaded sutures on the spiral side.

Carter & Hart (1977) record an increase in ornamentation associated with an increase in the height of the spire during the Upper Cenomanian (Carter & Hart Zone 13). Extreme variants were recognised as Praeglobotruncana stephani var. turbinata by Reichel (1950) but are just 'end-members' of the Praeglobotruncana plexus. This climax in the complexity of ornament and in the height of the spire during the Upper Cenomanian where Carter & Hart (1977) record all the variants of the Praeglobotruncana plexus is not readily apparent in the present study because of contamination by caving.

Size: Diameter : 0.33mm
Thickness : 0.20mm

Distribution: this species has its highest occurrence in the Early Turonian (Zone F.I.10) of all the studied well sections and is recorded rarely to moderately abundantly throughout.

Genus GLOBOTRUNCANA Cushman 1926
Type species Pulvinulina arca Cushman 1926

Globotruncana arca (Cushman 1926)
(Pl.13, fig,1a,b,c)

1926b Pulvinulina arca Cushman, p.23, pl.3, fig.1.

1927b Globotruncana arca (Cushman); Cushman, p.169, pl.28, fig.15.

non1931 " " (Cushman); Plummer, pp.195-198, pl.13, ?fig.8, non. figs. 7,9,11.

1937 " " (Cushman); Glaessner, pp.36-37, pl.1, fig.10.

1951 " " (Cushman); Bandy, p.509, pl.75, fig.1.

1953 " " (Cushman); Hagn, p.97, pl.8, fig.11.

p1955 " " arca (Cushman); Gandolfi, pp.63-64, pl.5, figs.2,3, non fig.4.

1956 " " (Cushman); Brönnimann & Brown, pp.539-540, pl.23, figs.10-12.

1959 " " (Cushman); Banner & Blow, pl.3, fig.5.

1960 " leupoldi Bolli; Olsson, p.50, pl.11, figs.1-3.

1962 " arca (Cushman); Barr, p.567, pl.69, fig.8.

1962 " (Globotruncana) arca (Cushman); Berggren, pp.49-51, pl.9, figs.1,2.

1964 " arca (Cushman); Olsson, pp.162-163, pl.4, figs.1-3.

1964 " " (Cushman); Loeblich & Tappan, p.C662, fig.529, nos.1-2.

1965 " " (Cushman); van Hinte, p.20, pl.2, fig.3, pl.3, fig.3.

1967 " " (Cushman); Pessagno, pp.321-323, pl.79, figs.5-8, pl.90, figs.6-8, pl.96, figs.7,8,17.

1969 " " (Cushman); Douglas, p.176, pl.9, figs.1-3, pl.10, figs.4-7.

1971 " " (Cushman); Postuma, p.18, pl.3, figs.1-7.

1972 " " (Cushman); Hanzlikova, p.102, pl.26, figs.11-13, pl.27, fig.1.

1973 " " (Cushman); Smith & Pessagno, pp.43-44, pl.18, figs.1-6.

1977 " " (Cushman); Masters, pp.536-540, pl.38, figs.1,2,4.

1977 " " (Cushman); Rodriguez, pp.237-246, pl.26, figs.2,3, ?pl.26, fig.4.

1981 " " (Cushman); Frerichs & Dring, pl.5, figs.1-3

1981 " " (Cushman); Gazdzicka, pl.22, fig.1.

1984 " " (Cushman); Robaszynski et al., pp.182-184, pl.4, figs.1-3.

Description: test free, moderate trochospire, biconvex; outline subcircular and lobate, with the equatorial periphery truncated by two, well developed, beaded keels; chambers distinct, inflated, and petaloid with five and a half to seven in the final whorl and increasing gradually in size as added; sutures distinct, slightly curved and raised umbilically, curved, raised and beaded spirally; aperture interiomarginal, umbilical, umbilicus deep and broad, covered by a tegilla.

Remarks: this species was originally described from Mexico (Cushman 1926), probably from the Upper Maastrichtian (Smith & Pessagno 1973). G. arca has had a confused history because included in Cushman's original description was a figure of a single-keeled specimen of the Globotruncana stuarti lineage group, together with the double keeled holotype (eg. Bolli 1951; Brönnimann & Brown 1956; Berggren 1962; Pessagno 1967). This has led to numerous erroneous identifications in the literature.

The robust biconvex test, quite widely spaced, beaded keels and the six to seven chambers in the final whorl characterise this species.

Size: Diameter : 0.35mm

Thickness : 0.26mm

Distribution: this species 'tops' within the Early Maastrichtian (Zone F.I.2) of well 44/2-1 and within the Late Campanian (Zone F.I.3) of well 49/19-1. It is recorded only rarely and sporadically from these two well sections.

Globotruncana bulloides Vogler 1941

(Pl.13, fig.2a,b,c)

1936 Globotruncana ventricosa White; Brotzen, pp.171-177, pl.13, fig.4

1941 " linnei (d'Orbigny) subsp. bulloides Vogler, p.287, pl.23, figs.29-32.

1945 " lapparenti bulloides Vogler; Bolli, pp.231-232, t. figs.17,18, pl.9, fig.12.

1946 Rosalinella marginata (Reuss); Schijfsma, pp.97-98, pl.7, fig.10.

1953 Globotruncana marginata (Reuss); Hagn, pp.93-94, pl.8, fig.10, figs.10,11.

1955 " bulloides bulloides Vogler; Gandolfi, p.32, pl.1, fig.9.

1957 " marginata (Reuss); Edgell, p.114, pl.2, figs.4-6.

1958 " lapparenti bulloides Vogler; Bieda, pp.58-59, t. fig.23.

1961 " paraventricosa (Hofker); Vasilenko, pp.151-154, pl.33, fig.1.

1962 " lapperenti bulloides Vogler; Pessagno, p.360, pl.6, figs.13,14.

1962 " marginata (Reuss); Barr, pp.574-575, pl.70, fig.3, pl.72, figs.7,8.

1962 " culverensis Barr, pp.569-570, pl.71, fig.1.

1962 " paraventricosa (Hofker); Hiltermann & Koch, p.331, pl.49, figs.6,7.

1965 ____" marginata (Reuss); van Hinte, p.23,pl.1, fig.2.

1967 ____" bulloides Vogler; Pessagno, pp.324-326, pl.64, figs.15-17, pl.67, figs.1-3.

1967 ____" linneiana bulloides Vogler; Bandy, p.19, t.fig.9, no.1.

1969 ____" marginata (Reuss); Douglas, pp.182-183, pl.8, fig.5,?4.

1969 ____" " (Reuss); Douglas & Rankin, pp.203-207, figs.14,15.

1970 ____" bulloides Vogler; Porthault in Donze et al., p.83, pl.11, figs.20-22.

1971 ____" " Vogler; Postuma, pp.20-21, pl.4, figs.1-7

1977 ____" " Vogler; Rodriguez, pp.296-303, pl.35, figs.1,2.

1977 ____" paraventricosa (Hofker); Koch, p.39, pl.4, figs.1-4

1981 ____" bulloides Vogler; Frerichs & Dring, p.69, pl.4, figs.16-18.

1981 ____" " Vogler; Hart et al.,in Jenkins & Murray, p.200, pl.7.14, figs.3-5.

1984 ____" " Vogler; Robaszynski et al., p.186, pl.6, figs.1-4.

Description: test free, low trochospire, biconvex, outline subcircular and moderately lobate, with the equatorial periphery truncated by two, well developed beaded keels; chambers distinct, inflated, with five to seven in the final whorl, increasing slowly to moderately in size as added; sutures distinct, slightly curved and depressed umbilically, curved, raised and beaded spirally; aperture umbilical, umbilicus moderately wide with evidence for the development of a tegilla, although rarely preserved.

Remarks: this species was first described from the Upper Cretaceous of the East Indies (Vogler 1941), originally from a sample in thin section; this has led to confusion in the past with Marginotruncana marginata (Reuss 1845). The situation was partially clarified by comparative thin section studies by Pessagno (1967).

G. bulloides may be a senior synonym of G. praeventricosa (Hofker), but the poor illustrations and type description of the latter makes the exact relationship between the two difficult to comment on.

Size: Diameter : 0.35mm
Thickness : 0.27mm

Distribution: this species is recorded rarely to moderately abundantly in all the studied well sections, 'topping' within the Late Campanian (Zone F.I.3) of well 44/2-1, within the mid-Campanian (Zone F.I.4) of well 49/19-1 and within the Early Campanian (Zone F.I.5) of well 49/20-2.

Globotruncana contusa (Cushman 1926)

(Pl.13, fig.3a, b, c)

1926 Pulvinulina arca var contusa Cushman, p.23.
1928 Globotruncana conica var plicata White, pp.285-286, pl.38, fig.8a-c.
1941 " linnei calciformis Vogler, p.288, pl.24, fig.23.
1946 " arca var contusa (Cushman); Cushman, pp.150-151, pl.62, figs.6a-b.
1951 " contusa (Cushman); Bolli, p.196, pl.34, figs.7-9.
p.1955 " " (Cushman); Troelsen, pp.80-81, t.fig.2a-c, non.t.fig.2d-f,g.
1955 " " contusa (Cushman); Gandolfi, pp.53-54, pl.4, figs.3a-c.

p.1964 " " (Cushman); Olsson, pp.163-164, pl.3, figs.6a-c, pl.2, figs.5a-c, non pl.3, figs.9a-c

1966 " " contusa (Cushman); El-Naggar, pp.90-93, pl.7, figs.2a-c, 3a-c, pl.11, figs.1a-b.

1966 " " witwickae El-Naggar, pp.95-97, pl.7, figs.1a-c.

p.1967 " " (Cushman); Pessagno, pp.330-333, pl.77, figs.4-6, 7-9, pl.78, figs.6-8, 9-11, pl.92, figs.10-12, pl.96, figs.14-16, non pl.75, figs.18-20, non pl.77, figs.1-3, non pl.96, figs.11,13.

1972 " " (Cushman); Barr, p.19, pl.7, figs.7a-c.

1973 " " (Cushman); Smith & Pessagno, pp.45-46, pl.21, figs.1-5.

1981 " " (Cushman); Hart et al., in Jenkins & Murray, p.200, pl.7.14, figs.6,7.

1984 Rosita contusa (Cushman); Robaszynski et al., pp.246-248, pl.36, figs.1,2, pl.37, figs.1,2,3.

Description: test free, high trochospire, spiro-convex and deeply umbilicate; outline subcircular and weakly lobate, with the equatorial periphery truncated by two closely spaced keels; chambers distinct, elliptical to subrectangular umbilically, elongate, crescentric and typically highly crenulate spirally, with five to seven in the final whorl; sutures distinct, depressed, radial and slightly curved umbilically, curved, raised and highly beaded spirally; aperture interiomarginal, umbilical.

Remarks: this species was originally described by Cushman (1926) from the Mendez Shale (Maastrichtian), in Mexico. It is characterised by the trochospiral, strongly spiroconvex and deeply umbilicate test, the polygonal and undulating peripheral outline and strongly plicated spiral surface.

Troelsen (1955) described two distinct forms of this species from the Kjølby Gaard Marl (Maastrichtian) of Denmark; a plicate form that agreed very well with Cushman's holotype and paratypes (deposited in the U.S. National Museum), and a second, nonplicate form. As Troelsen observed that the nonplicate form graded into the plicate form, he included both in G. contusa (Cushman).

Similar transitional stages between G. contusa and a nonplicate form were also noted by Gandolfi (1955), and he referred the nonplicate forms to G. contusa patelliformis, whilst retaining the name G. contusa contusa for the plicate, larger forms.

After examining the holotype and unfigured paratypes of G. contusa witwickae El-Nagger, Pessagno (1973) concluded them to be conspecific with G. contusa, differing only in being lower spired. Two of the unfigured paratypes appear to be conspecific with G. patelliformis Gandolfi.

Size: Diameter : 0.60mm
Thickness : 0.52mm

Distribution: very rare specimens assignable to this species were only recovered from well 44/2-1, having their highest occurrence within the Early Maastrictian (Zone F.I.2).

Globotruncana linneiana (d'Orbigny 1839)

(Pl.14, fig.1a,b,c)

1839 Rosalina linneiana d'Orbigny, p.110, pl.5, figs.10-12.

pl918 " " d'Orbigny; de Lapparent, pp.1-17, t.fig.2g, non figs.2a-f, h-n.

1941 Globotruncana linnei typica (d'Orbigny); Volger, p.286, pl.23, figs.12-22.

1945 " lapparenti lapparenti Brotzen; Bolli, p.230, pl.9, fig.11, t.fig.1, no.15,?16.

1951 " canaliculata (Reuss); Bandy, p.509, pl.75, fig.2.

1956 " linneiana (d'Orbigny); Brönnimann & Brown, pp.540-542, pl.20, figs.13-17,pl.21, figs.16-18. Neotype.

1961 " " (d'Orbigny); Graham & Clark, p.113 pl.5, fig.11.

1962 " lapparenti lapparenti Brotzen; Herm, pp.82-84, pl.6, fig.2.

1962 " linneiana linneiana (d'Orbigny); Barr, pp.571-72, pl.69, fig.7, pl.72,fig.5.

1967 " " " (d'Orbigny); Bandy, p.19, t.fig.8, no.11.

1967 " " (d'Orbigny); Pessagno, pp.346-349, pl.72, figs.1-4, 7-9, pl.79, figs.11-13.

1969 " " (d'Orbigny); Douglas, pp.181-182, pl.3, fig.1.

1971 " lapparenti Brotzen; Postuma, p.48, pl.18, figs.1-7.

1972 " linneiana (d'Orbigny); Barr, pp.21-22, pl.9, fig.2.

non1972 " " (d'Orbigny); Hanzlikova, pp.107-108, pl.29, figs.6-7.

1976 " " (d'Orbigny); Wright & Apthorpe, p.239, pl.1, figs.8,11.

1976 " lapparenti Brotzen; Wright & Apthorpe, p.239, pl.1, figs.12,13.

1977 " " Brotzen; Masters, pp.579-583, pl.46, fig.4.

non1977 " linneiana (d'Orbigny); Masters, pp.583-585, pl.46, figs.3,5,6.

1977 " " (d'Orbigny); Rodriguez, pp.258-263, pl.29, figs.4,5, pl.30, figs.1,2.

?1981 " lapparenti Brotzen; Frerichs & Dring, p.69, pl.4, figs.19-21.

1981 " linneiana (d'Orbigny); Hart et al., in Jenkins & Murray, p.200, pl.7.14, figs.11,12.

1984 " " (d'Orbigny); Robaszynski et al., pp.200-202, pl.13, figs.1-4, pl.14, figs.1-5.

Description: test free, low trochospire of two and a half to three and a half whorls, both spiral and umbilical sides almost flat; outline subcircular and weakly lobate, with the equatorial periphery truncated by two widely spaced keels; chambers distinct, elongate and subrectangular umbilically, petaloid spirally, five to seven in the final whorl, increasing gradually in size as added; sutures distinct, raised, beaded and curved; aperture interiomarginal, umbilical and covered by a tegilla, umbilicus wide, moderately shallow and bordered by a distinct beaded umbilical shoulder.

Remarks: this species was first described from Recent beach sands on Cuba (d'Orbigny 1839) and has a very confused taxonomic history. D'Orbigny's original figures were stylized and unclear but show a form with possible radial and depressed sutures umbilically. In 1918, de Lapparent referred a syntypic suite of specimens to G. linneiana with sigmoidal, umbilical sutures. On this basis, Brotzen (1936) considered them a new species, G. lapparenti. In 1956, Brönnimann & Brown erected a neotype of Rosalina linneiana d'Orbigny, but chose a form with raised, beaded, sigmoidal sutures umbilically, which can probably be referred to G. lapparenti Brotzen. No holotype was designated by Brotzen for G. lapparenti further complicating the situation; he only refers to a suite of specimens which probably include more than one species (Pessagno 1967).

Bolli's (1945) figured specimens of G. lapparenti are conspecific with the neotype of G. linneiana. Pessagno (1967) tried to clarify the situation by formally designating as lectotype for G. lapparenti the specimen in thin section in text fig. 2n (de Lapparent 1918), distinguishing this species from G. linneiana by the narrower keels and more inflated final chamber with a prominant umbilical shoulder.

There is a continuous morphological gradation from Marginotruncana pseudolinneiana Pessagno to G. linneiana.

Size: Diameter : 0.32mm
Thickness : 0.20mm

Distribution: this species has its highest occurrence within the Late Campanian (Zone F.I.3) of well 44/2-1, at the base of the Late Campanian (Zone F.I.3) of well 49/20-2 and within the mid-Campanian (Zone F.I.4) of well 49/19-1. It is recorded rarely to abundantly throughout the studied well sections.

Genus ABATHOMPHALUS Bolli, Loeblich & Tappan 1957
Type species Globotruncana mayaroensis (Bolli 1951)

Abathomphalus intermedius (Bolli 1951)
(Pl.14, fig.2a,b,c)

1951 Globotruncana intermedia Bolli, pp.197-198, pl.35, figs.7-9.
1955 " " intermedia Bolli; Gandolfi, pp.48-49, pl.3, fig.8.
?1956 Rugotruncana intermedia (Bolli); Brönnimann & Brown, p.553, pl.22, figs.13-15.
1962 Praeglobotruncana (Praeglobotruncana) intermedia (Bolli); Berggren, p.31, pl.7, fig.2.
1967 Globotruncana intermedia Bolli; Bandy, p.19, t.fig.9, no.2.

?1969 Abathomphalus intermedia (Bolli); Funnell et al., p.27, pl.2, figs.8-18, t.fig.10.

1969 Praeglobotruncana intermedia (Bolli); Hanzlikova, pp.46-47, pl.9, figs.5,6, ?fig.4.

1972 Abathomphalus intermedia (Bolli); Hanzlikova, p.113, pl.32, ?figs.1,2, fig.3.

1977 Globotruncana intermedia (Bolli); Masters, pp.576-578.

1977 Abathomphalus intermedia (Bolli); Rodriguez, pp.370-373, pl.47, fig.1, ?fig.2.

1983 " intermdius (Bolli); Solakius, pp.144-145, pl.1, figs.6,9, 10-12, pl.2 figs.4-9, pl.4, figs.1-7.

1984 " " (Bolli); Robaszynski et al. p.272, pl.45, figs.2-4, 7, pl.46, figs.1,2.

Description: test free, low trochospire of two and a half to three whorls, spiral side weakly convex and umbilical side slightly concave to flat; outline subcircular to ovoid and moderately lobate, with the equatorial periphery truncated by two closely spaced, weakly developed keels; chambers distinct, initially small and inflated, becoming relatively larger and subglobular with four to five chambers in the final whorl, subtriangular on the umbilical side, subpetaloid on the spiral side; sutures distinct, depressed and radial on the umbiical side curved raised and beaded on the spiral side; aperture a low interiomarginal, extraumbilical opening; umbilicus shallow covered by a tegillum; wall calcareous and perforate, surface pustulose.

Remarks: this species was originally described from the Upper Maastrichtian of Trinidad (1951). This species is intermediate between Globotruncanella havanensis (Voorwijk 1937) and Abathomphalus mayaroensis (Bolli 1951).

Size: Diameter : 0.23mm

Thickness : 0.14mm

Distribution: very rare specimens referable to this species were only recorded from well 44/2-1, having the highest occurrence within the Early Maastrichtian (Zone F.I.2).

Abathomphalus mayaroensis (Bolli 1951)

(Pl.14, fig.3a,b,c)

1951 Globotruncana mayaroensis Bolli, p.198, pl.35, figs.10-12.

1956 Rugotruncana mayaroensis (Bolli); Brönnimann & Brown, pp.553-554, pl.22, figs.10-12.

1957 Abathomphalus mayaroensis (Bolli); Bolli, Loeblich & Tappan, p.43, pl.11, fig.1.

1957 Globotruncana (Globotruncana) planata Edgell, p.115, pl.4, figs.7-9.

non1958 " mayaroensis Bolli; Witwicka, p.225, pl.18, fig.36.

1962 Praeglobotruncana (Praeglobotruncana) mayaroensis (Bolli); Berggren, pp.32-36, pl.7, fig.3.

1964 Abathomphalus mayaroensis (Bolli); Loeblich & Tappan, p.C 663, fig.529, no.5.

1967 " " (Bolli); Pessagno, p.372, pl.92, figs.4-9, pl.95, fig.5.

1967 Globotruncana mayaroensis (Bolli); Bandy, p.20, t.fig.9, no.3.

1969 Abathomphalus mayaroensis (Bolli); Hanzlikova, p.47, pl.9, figs.7,8.

1971 Globotruncana " Bolli; Postuma, p.50, pl.19, figs.1-7.

1972 Abathomphalus " (Bolli); Hanzlikova, p.114, pl.32, figs.5,6, ?fig.4.

1977 " " (Bolli); Rodriguez, pp.373-376, pl.47, figs.3,4.

1977 Globotruncana mayaroensis Bolli; Masters, p.591-593, pl.48, figs.1-5.

1981 Abathomphalus mayaroensis (Bolli); Hart et al., in Jenkins & Murray, pp.180-181, pl.7.4, figs.1-3.

1983 " " (Bolli); Solakius, p.147, pl.2, figs.10-12.

1984 " " (Bolli); Robaszynski et al., p.274, pl.45, figs.5,6,9, pl.46, fig.5.

Description: test free, low trochospire of two and a half to three whorls, spiral side weakly convex and umbilical side slightly concave; outline subcircular and lobate, with the equatorial periphery truncated by two widely spaced, strongly beaded keels; chambers distinct, subglobular and depressed with the last chamber more globular and inflated than those proceeding, four to five in the final whorl; sutures distinct, straight, radial and depressed on the umbilical side, crescentric, raised and weakly beaded on the spiral side; aperture interiomarginal, extraumbilical; umbilicus shallow and covered by a tegilla.

Remarks: this species was originally described from the Maastrichtian of Trinidad (Bolli 1951), and can be distinguished by its shallow umbilicus and apertural characteristics A. mayaroensis probably arose from Globotruncanella havanensis (Voorwijk) via Abathomphalus intermedius (Bolli) during the Maastrichtian (e.g. Berggren 1962; Pessagno 1967; Swiecicki 1980 (unpubl); Solakius 1983).

Size: Diameter : 0.40mm

Thickness : 0.19mm

Distribution: extremely rare examples of this species were recorded from the Early Maastrichtian (Zone F.I.2) of wells 44/2-1 and 49/19-1.

Genus ARCHAEOGLOBIGERINA Pessagno 1967

Type Species Archaeoglobigerina blowi Pessagno 1967

Archaeoglobigerina cretacea (d'Orbigny 1840)

(Pl.14, fig.4a,b,c)

1840 Globigerina cretacea d'Orbigny, p.34, pl.3, figs.12-14.

1936 Globotruncana globigerinoides Brotzen, p.177, pl.12, fig.3, pl.13, fig.3.

1941 Globigerina cretacea d'Orbigny; Marie, p.234, pl.36, fig.335.

1946 Rosalinella globigerinoides (Brotzen); Schijfsma, pp.96-97, pl.7, fig.9.

1951 Globotruncana globigerinoides Brotzen; Noth, p.76, pl.5, fig.4.

1956 Globotruncana saratogaensis (Applin); Brönnimann & Brown, p.544-545, pl.21, figs.1-3.

1957 " (Globotruncana) globigerinoides Brotzen; Edgell, pp.112-113, pl.21, figs.13-15.

1958 " globigerinoides Brotzen; Bieda, pp.65-66, t.fig.27.

1960 " cretacea (d'Orbigny); Banner & Blow, pp.8-10, pl.7, fig.1. (Lectotype)

1961 Globigerina cretacea (d'Orbigny); Hofker, pl.1, figs.15-17.

1962 Globotruncana cretacea (d'Orbigny); Barr, pp.567-569, pl.69, fig.9.

1963 " (Globotruncana) cretacea (d'Orbigny); van Hinte, pp.85-86, pl.6, fig.3.

1965 " cretacea (d'Orbigny); van Hinte, p.21, pl.3, fig.1.

1967 Rugoglobigerina cretacea (d'Orbigny); Bandy, p.21, t.fig.10, no.1.

1967 Archaeoglobigerina cretacea (d'Orbigny); Pessagno, pp.317-318, pl.70, figs.3-8, pl.94, figs.4-5.

1969 Globotruncana cretacea (d'Orbigny); Douglas & Rankin, pp.200-203, t.fig.12.

1970 Archaeoglobigerina cretacea (d'Orbigny); Porthault in Donze et al., pp.539-540, pl.9, fig.17.

1972 Globotruncana cretacea (d'Orbigny); Hanzlikova, p.108, pl.28, figs.3-5.

1977 Archaeoglobigerina cretacea (d'Orbigny); Rodriguez, pp.72-77, pl.4, figs.1,2.

1979 " " (d'Orbigny); Robaszynski & Caron, pp.173-176, pl.80, fig.1.

1980 " " (d'Orbigny); Gawor-Biedowa, p.39, pl.7, figs.4-6.

1981 " " (d'Orbigny); Hart et al., in Jenkins & Murray, p.180, pl.7.4, figs.6,7.

1981 " " (d'Orbigny); Frerichs & Dring, pl.3, figs.13-15.

1984 " " (d'Orbigny); Robaszynski et al., p.278, pl.47, figs.3-6, pl.48, fig.2.

Description: test free, low trochospire with subcircular and moderately lobate outline, periphery weakly truncated with two weakly developed, faint keels bordering a raised imperforate band; chambers distinct, inflated and subglobular, arranged in two and a half to three whorls, increasing gradually and uniformly in size as added; sutures radial, depressed and straight on the umbilical side, depressed and nearly radial on the spiral side; primary aperture umbilical, umbilicus broad and deep and covered by tegilla.

Remarks: this species was originally described and figured from the Campanian chalk of St. Germain in the Paris Basin (1840).

Banner & Blow (1960) erected and figured a lectotype for this species after examining d'Orbigny's collection in Paris. Their diagnosis of the species follows the original description but revealed for the first time the presence of two faint keels separated by an imperforate band; other

specimens in d'Orbigny's collection have well developed tegillae. Considering all these characteristics, Banner and Blow (1960) assigned the species to the genus Globotruncana; its homonym Globotruncana cretacea Cushman 1938 (non d'Orbigny 1840) was renamed Globotruncana mariei Banner & Blow 1960.

Pessagno (1967) erected the new genus Archaeoglobigerina to which the present species is referred on the basis of its non-truncate, globular chambers and radial depressed sutures umbilically.

Globotruncana globigerinoides Brotzen was originally distinguished from A. cretacea by the presence of a weak, double keel, and is therefore a junior synonym.

Size: Diameter : 0.35mm
Thickness : 0.24mm

Distribution: this species first appears "downhole" at the base of the Early Maastrichtian (Zone F.I.2) in wells 44/2-1 and 49/20-2, and in the Late Campanian (Zone F.I.3) of well 49/19-1. It is recorded rarely to commonly throughout the studied sections.

Genus GLOBOTRUNCANELLA Reiss 1957

Type species Globotruncana citae Bolli 1951 (=Globotruncana havanensis Voorwijk 1937)

Globotruncanella havanensis (Voorwijk 1937)
(Pl.15, fig.1a,b,c)

1937 Globotruncana havanensis Voorwijk, p.195, pl.1, figs.25, 26, 29.

1951 " citae Bolli, p.197, pl.35, figs.4-6.

1956 Rugotruncana havanensis (Voorwijk); Brönniman & Brown, p.552, pl.22, figs.4-6.

1956d Marginotruncana citae (Bolli); Hofker, p.334, fig.25.

1957 Globotruncana (Globotruncana) citae Bolli; Edgell, p.111, pl.1, figs.13-15.

1960 " (Rugotruncana) havanensis Voorwijk, Pessagno, p.103.

1960 " citae Bolli; Hofker, p.225, t.fig.20a-c.

1962 Praeglobotruncana havanensis (Voorwijk); Berggren, pp.26-30, pl.7, fig.1.

1963 Globotruncanella havanensis (Voorwijk); van Hinte, pp.94-96, pl.11, figs.4,5, pl.12, fig.1, ?pl.10, fig.3.

1964 Globotruncana havanensis Voorwijk; Loeblich & Tappan, p.C662, fig.529, no.3.

1967 Praeglobotruncana havanensis havanensis (Voorwijk); Bandy, p.18, t.fig.10, no.11.

1967 Globotruncanella havanensis (Voorwijk); Pessagno, p.373, pl.84, figs.1-3.

1968 Globotruncana havanensis Voorwijk; Sliter, pp.103-104, pl.17, figs.1,2.

1969 Globotruncanella havanensis Voorwijk; Douglas, p.190, pl.10, fig.3.

1971 Praeglobotruncana citae (Bolli); Postuma, pp.70-71, pl.28, figs.1-7.

1972 Globotruncana havanensis (Voorwijk); Hanzlikova, pp.105-106, pl.29, figs.2-5.

1977 Globotruncanella havanensis (Voorwijk); Rodriguez, pp.356-358, pl.45, figs.3-6.

1977 " " (Voorwijk); Koch, p.61, pl.7, figs. 9,10.

1981 _____ " _____ " _____ (Voorwijk); Hart et al., in Jenkins & Murray, pp.202-203, pl.7.15, figs.1,2.

1983 _____ " _____ " _____ (Voorwijk); Solakius, pp.147-148, pl.2, figs.1-6.

1984 _____ " _____ " _____ (Voorwijk); Robaszynski et al., p.265, pl.44, figs.4-6.

Description: test free, compressed and small; low trochospire of two whorls, spiral side slightly convex and umbilical side slightly concave; outline subquadrate to ovoid, with acute to subacute periphery, possibly with an imperforate marginal band; chambers distinct, compressed and petaloid and slightly inflated on the spiral side, four to five in the final whorl and increasing slowly in size as added; sutures distinct, slightly curved, flush to weakly depressed on the spiral side; aperture a high umbilical-extraumbilical arch, umbilicus narrow and deep and maybe covered by a delicate tegilla, wall calcareous and finely perforate, surface may be initially coarsely spinose.

Remarks: this species was originally described by Voorwijk (1937) from the Maastrichtian of Cuba and later as Globotruncana citae from the Maastrichtian of Trinidad by Bolli (1951).

The thin, compressed test, lobate periphery and depressed sutures make this a very distinct species. G. havanensis possibly evolved from 'whiteinellid' stock in the Late Campanian (Swiecicki 1980 (unpubl.); Hart et al. 1981), and gave rise to Abathomphalus mayaroensis (Bolli) during the Maastrichtian (eg. Berggren 1962; Pessagno 1967; Swieciki 1980 (unpubl.); Solakius 1983).

Size: Diameter : 0.25mm

Thickness : 0.14mm

Distribution: very rare specimens assignable to this species were recorded sporadically from wells 44/2-1 and 49/19-1 only, 'topping' within the Late Maastrichtian (Zone F.I.1) in the former and in the mid-Campanian (Zone F.I.4) in the latter.

Genus MARGINOTRUNCANA Hofker 1956

Type species Rosalina marginata Reuss 1845

Marginotruncana marginata (Reuss 1845)

(Pl.15, fig.2a,b,c.)

1845 Rosalina marginata Reuss, p.36, pl.8, figs.54a,b, 74a,b, pl.13, fig.68a,b.

1910 Globigerina marginata (Reuss); Heron-Allen & Earland, p.424, pl.9, figs.1-3.

1946 Rosalinella " (Reuss); Schijfsma, pp.97-98, pl.7, fig.10a-c.

1946 Globotruncana marginata (Reuss); Cushman, p.150, pl.62, figs.1,2.

1955 " intermedia difformis (Reuss); Gandolfi, p.49, pl.3, figs.4a-c, 5a-c.

1956 Marginotruncana marginata (Reuss); Hofker, pp.522-524, t.figs.6a-f, 7, 8a-d.

pl1956 Globotruncana " (Reuss); Jirova, pp.248-249, pl.3, fig.1a-c, (non pl.1, figs.1-3, pl.2, figs.1-2, pl.3, figs.2-3).

1967 Marginotruncana marginata (Reuss); Pessagno, pp.307-310, pl.54, figs.10-12, 16-18, pl.56, figs.10-12, pl.99, figs.5-7.

pl1969 Globotruncana " (Reuss); Douglas, pp.182-183, pl.8, fig.4, (non fig.5).

1970 Marginotruncana marginata (Reuss); Porthault, in Donze et al., p.74, pl.10, figs.18-20, pl.13, figs.21,23.

1973 Globotruncana " (Reuss); Norling, in Bergstrom et al., p.111, pl.8, fig.1a-c.

1979 Marginotruncana marginata (Reuss); Robaszynski & Caron (part 2), pp.108-114, pl.63, figs.1a-c, 2a-d,

pl.64, figs.1a-c, 2a-d.

1980 ____"____"____ (Reuss); Gawor-Biedowa, pp.35-36, pl.4, figs.8,9,10.

1981 ____"____"____ (Reuss); Frerichs & Dring, p.68, pl.5, figs.4-6.

Description: test free; low trochospire; bioconvex; periphery with two closely spaced keels; chambers globular, petaloid with five to eight (commonly five or six) in the final whorl; sutures depressed, radial on umbilical side and marked by 'U' shaped sigmoidal rims, depressed to slightly raised and oblique on spiral side; primary aperture extraumbilical-umbilica; umbilicus wide and shallow.

Remarks: this species was originally described by Reuss from the Plänner Marl, Bohemia (1845). However, the original figures are very small and the important characteristics are not clear. Reuss also neglected to figure a side view of the holotype. In 1854 Reuss illustrated the same species from the Gosau Beds, Gosautal, Austria with large and clear figures including a side view showing the presence of two, thin, narrow keels around the periphery. In 1946, Cushman figured three views of a specimen from the Reuss collection at Cambridge and two thin keels are again clearly shown, separated by a narrow imperforate peripheral band. The umbilical sutures are shown to be bordered by 'U' shaped rims.

In 1956, Hofker erected the genus Marginotruncana designating Rosalina marginata (Reuss 1845) as the type species. Reuss's original description of R. marginata describes the species as being double keeled, but the form Hofker illustrated as the type species for the genus has only a single keel. At the same time Hofker assigns the single keeled Praeglobotruncana turbinata (Reichel) to this new genus. As the genus is defined on a species that was originally described with two keels, Hofker's taxonomic designations are not acceptable and the

genus has since been amended (Pessagno 1967; Porthault 1970). The genus is now restricted to species possessing elevated sigmoidal sutures on the umbilical side (forms with radial depressed sutures have been assigned to the genus Dicarinella), with two keels and an extraumbilical-umbilical primary aperture.

The loss of Reuss's original material necessitated the selection of a neotype which was chosen out of a population from the type-locality by Jirova (1956). Jirova's concept of the species includes a wide range of variation exceeding that illustrated by Reuss. The neotype has two quite thick, widely spaced keels and is more representative of Dicarinella canaliculata (Reuss 1854) which was described from the same section as M. marginata. However, Robaszynski & Caron (1979) consider Jirova's specimen (figured in Plate 3, fig.1a-c) to fall within the variability of marginata.

In 1955, Gandolfi erected the subspecies Globotruncana intermedia difformis which has two, thin, closely spaced keels and radial sutures. After examining the holotype Pessagno (1967) concluded that this subspecies was assignable to M. marginata (p.310) and thus considers G. intermedia difformis a junior synonym.

Globotruncana bulloides Vogler 1941 can be distinguished from M. marginata by its better developed keels, the truncate profile and the umbilical primary aperture.

M. marginata can be distinguished from Dicarinella canaliculata by its two less developed keels and umbilical sutures marked by a sigmoidal U-shaped rim.

Size: Diameter : 0.45mm

Thickness : 0.27mm

Distribution: the Late Santonian interval in wells 49/19-1 and 49/20-2 is characterised by the appearance of this species where it is recorded commonly, becoming common to abundant in the Early Santonian (Zone F.I.7) to Early Turonian (Zone F.I.9) interval. In well 44/2-1 this species appears in the Early Santonian (zone F.I.7), and is recorded commonly to abundantly throughout the section.

Marginotruncana pseudolinneiana Pessagno 1967

(Pl.15, fig.3a,b,c)

1960 Globotruncana lapparenti tricarinata (Quereau); Tollmann, pp.193-194, pl.21, figs.1a-c.

1966 " linneianna (d'Orbigny); Caron, p.83, pl.5, fig.3a-c.

1967 Marginotruncana pseudolinneiana Pessagno, p.310, pl.65, figs.24-27, pl.76, figs.1-3.

1970 " " Pessagno; Porthault in Donze et al., p.79, pl.11, figs.9,10, pl.13, figs.19,22.

1979 " " Pessagno; Robaszynski & Caron (part 2), pp.123-128, pl.67, fig.1a-c, 2a-d, pl.68, fig.1a-c, 2a-c.

1981 " " Pessagno; Frerichs & Dring, p.68, pl.4, figs.13-15.

1981 " " Pessagno; Hart et al., in Jenkins & Murray, p.210, pl.7.19, figs.8,9.

Description: test free; low trochospire; rectangular profile with both sides flat, sometimes convex spirally and concave umbilically; periphery truncated by a double keel separated by a wide band; chambers lobate on the umbilical side, elongate, petaloid on the spiral side,

five to seven in the final whorl; sutures sigmoid, raised on the umbilical side, raised and curved on the spiral side but slightly flattened towards the margins; primary aperture extraumbilical-umbilical, low, interiomarginal arch; umbilicus wide; no tegilla recorded.

Remarks: this species was originally described and figured from a marl of Late Coniacian-Early Santonian age, of the Lower Gosau beds, Gosautal, Edelbachgraben, Austria (Pessagno 1967). The illustrations of the holotype and paratype clearly show the homeomorphic relationship of this species and Globotruncana linneiana (d'Orbigny 1839). There is a continuous morphological gradation from M. pseudolinneiana to G. linneiana (Hart et al. 1981) the two differing only in the position of the primary aperture - the former having an extraumbilical-umbilical aperture whereas the latter has an umbilical aperture.

This species can be distinguished from Marginotruncana marginata (Reuss 1845) by its sigmoidal umbilical sutures, stronger and more widely spaced keels and by the rectangular profile.

Size: Diameter : 0.32mm
Thickness : 0.17mm

Distribution: this species 'tops' within the Early Santonian (Zone F.I.7) of all the studied wells and is generally recorded commonly to abundantly throughout the sections.

Genus RUGOGLOBIGERINA Brönnimann 1952

Genotype Globigerina rugosa (Plummer 1927)

Rugoglobigerina milamensis Smith & Pessagno 1973

(Pl.16, figs.1a,b,c)

1957 Rugoglobigerina rugosa (Plummer); Edgell, pp.116-118, pl.4, figs.10-12.

p1962 " " (Plummer); Berggren, pp.71-75, pl.11, figs.3,5, non. figs.1,2,4.

p1964 " " (Plummer); Olsson, p.173, pl.7, figs.3,?4, non.figs.2,5.

p1966 " rotundata Brönnimann; Douglas & Sliter, p.116, pl.1, fig.5, non-figs.2,6.

p1972 " pennyi Brönnimann; Hanzlikova, p.114, pl.33, figs.1,3, non.fig.2.

1973 " milamensis Smith & Pessagno, pp.56-57, pl.24, figs.4-7.

?1976 " pilula Belford; Wright & Apthorpe, p.240, pl.2, fig.10.

1977 " rotundata Brönnimann; Sliter, p.543, pl.11, figs.1-3.

1984 " milamensis Smith & Pessagno; Robaszynski et al. p.284, pl.50, fig.3.

Description: test free, high trochospire of two and a half to three whorls; strongly spiroconvex; chambers inflated and globular, initially moderately increasing in size as added with five to six in the final whorl only gradually increasing in size with the last chamber slightly offset umbilically; sutures distinct, radial, depressed and straight to slightly curved; primary aperture interiomarginal, umbilical; umbilicus large, deep and subrectangular; surface heavily rugose, with closely spaced costellae aligned in a meridional pattern.

Remarks: this species was originally originally described by Smith & Pessagno (1973) from the Corsicana Formation of Milam County, Texas, after which it is named. This species was previously figured as R.rugosa (Plummer) but was formally recognised as a separate species on the basis of the stronger trochospire and the slight rather than rapid increase in chamber size (Smith & Pessagno 1973, p.56). It can be distinguished from R. rotundata Brönnimann 1952 by its higher trochospiral coil, larger umbilicus, well developed meridional rugosities and chambers that are not strongly elongate axially.

R. milamensis was recorded in moderate abundance by Swiecicki (1980 unpublished) in the Maastichtian of Norfolk and the North Sea.

Size: Diameter : 0.36mm
Thickness : 0.38mm

Distribution: rare specimens of this species have only been recorded from the well 44/2-1, first appearing downhole within the Late Maastrichtian (Zone F.I.1.).

Rugoglobigerina rotundata Brönnimann 1952
(Pl.16, figs.2a,b,c)

1952 Rugoglobigerina rugosa rotundata Brönnimann, pp.34-36, pl.4, figs.7-9, t.fig.15,16.
1955 Globotruncana (Rugoglobigerina) rotundata rotundata (Brönnimann); Gandolfi, p.70, pl.7, fig.2.
1956 Kuglerina rotundata (Brönnimann); Brönnimann & Brown, p.557.
non1966 Rugoglobigerina rotundata Brönnimann; Douglas & Sliter, p.116, pl.1, figs.5,6.
1967 " " Brönnimann; Pessagno, pp.365-366, pl.65, figs.1-4, pl.68, figs.1-3.

1967 ___"___ rugosa rotundata Brönnimann; Bandy, p.22, t.fig.10, (no.5).

1969 ___"___ rotundata Brönnimann; Funnell et al., p.37, pl.5, figs.7-9, t.fig.21.

1971 ___"___ "___ Brönnimann; Postuma, p.88, pl.38, figs.1-7.

1972 ___"___ "___ Brönnimann; Barr, p.30, pl.10, fig.3.

?1973 ___"___ "___ Brönnimann; Smith & Pessagno, p.58, pl.24, figs.8-11.

non1977 ___"___ "___ Brönnimann; Sliter, p.543, pl.11, figs.1-3.

1977 ___"___ "___ Brönnimann; Masters, pp.621-622.

1984 ___"___ "___ Brönnimann; Robaszynski et al., p.288, pl.50, fig.2.

Description: test free, moderate trochospire of two and a half to three whorls; subspherical; chambers indistinct, initially globular but becoming elongated axially, moderately increasing in size as added with five to six in the final whorl; sutures radial and depressed, slightly curved on the spiral side, straight on the umbilical side; primary aperture interiomarginal, umbilical; umbilicus moderately narrow and deep; surface rugose with numerous pustules aligned in a weakly developed meridional pattern.

Remarks: this species was originally described by Brönnimann (1952) from the Guayaguayare Beds (Upper Maastrichtian) of Trinidad. In this original description, Brönniman (1952, p.36) noted the weak development of the ornamentation shown by this species in comparison with that observed for other species of Rugoglobigerina. This, together with the axially elongate chambers, subspherical test and small umbilicus distinguishes it from other members of the genus.

Size: Diameter : 0.27mm

Thickness : 0.20mm

Distribution: appearing within the Late Maastrichtian (Zone F.I.1) of wells 44/2-1 and 49/20-2, this species is recorded rarely to moderately commonly and sporadically throughout.

Rugoglobigerina rugosa (Plummer 1927)

(Pl.16, fig.3a,b,c)

1927 Globigerina rugosa Plummer, pp.38-39, pl.2, fig.10.

1952 Rugoglobigerina rugosa rugosa (Plummer); Brönnimann, pp.28-33, t.figs.11-13.

1955 Globotruncana (Rugoglobigerina) rugosa rugosa (Plummer); Gandolfi, p.72, pl.7, fig.6.

1957 Rugoglobigerina rugosa (Plummer); Bolli, Loeblich & Tappan, p.43,pl.11, fig.2.

non1957 " " (Plummer); Edgell, pp.116-118, pl.4, figs.10-12.

p1962 " " (Plummer); Berggren, pp.71-75, pl.11, figs.1-2, ?fig.4, non figs.3,5.

1963 Globotruncana (Rugoglobigerina) rugosa (Plummer); van Hinte, p.92, pl.11, figs.1-2, ?3.

p1964 Rugoglobigerina rugosa (Plummer); Olsson, p.173, pl.7, ?fig.4, non figs.2,3,5.

1964 " macrocephala Brönnimann; Olsson, p.172, pl.6, fig.9.

non1964 " rugosa (Plummer); Martin, p.83, pl.10, fig.6.

1964 " " (Plummer); Loeblich & Tappan, p.C663, fig.530, no.3.

1967 " " (Plummer); Pessagno, pp.366-367, pl.75, figs.2,3, pl.101, figs.8,9.

1967 " " (Plummer); Bandy, p.22, t.fig.10, no.6.

?1971a _____ " _____ (Rugoglobigerina) rugosa (Plummer); El-Naggar, pl.5, fig.a-c.

1971b _____ " _____ (") badryi El-Naggar, pp.482-483, pl.14, figs.2,5,9,10, pl.16, figs.1,3,7, ?figs. 4,5,11.

1971b _____ " _____ (") browni El-Naggar, pp.484-485, pl.17, figs.2,3,5,6,8.

1971b _____ " _____ (") rugosa (Plummer); El-Naggar, pp.492-494, pl.1, figs.1-11, pl.2, figs.1-12, pl.3, figs.1-16, pl.4, figs.1-16, pl.8, figs.4,5.

1971 _____ " _____ rugosa (Plummer); Postuma, p.90, pl.39,figs.1-7.

1972 _____ " _____ " (Plummer); Hanzlikova, p.116, pl.33, figs.5,6.

1973 _____ " _____ " (Plummer); Smith & Pessagno, pp.58-60, pl.25, figs.1-4.

1977 _____ " _____ " (Plummer); Rodriguez, pp.82-86, pl.4, figs.5-7.

1981 _____ " _____ " (Plummer); Hart et al., in Jenkins & Murray, p.218, pl.7.23, figs.7-9.

1984 _____ " _____ " (Plummer); Robaszynski et al., p.288, pl.49, figs.4,6.

Description: test free, low trochospire of two and a half to three whorls; chambers distinct and globular, rapidly increasing in size as added with four and a half to five in the final whorl; sutures depressed and radial, slightly curved on the spiral side, straight to slightly curved on the umbilical side; primary aperture interiomarginal, umbilical; umbilicus wide and deep; surface heavily rugose with closely spaced costellae aligned in a meridional pattern.

Remarks: this species was originally described by Plummer (1927) from the uppermost Corsicana Formation (mid Maastrichtian), Milam County, Texas. R. rugosa is characterised by its low trochospiral test, the rapidly expanding chambers and its large, deep umbilicus. This species exhibits a wide degree of variability with respect to the number of chambers in the final whorl, the rapidity of their increase in size as added and in the degree of development of meridionally arranged costellae. As such, this species has a complex taxonomic history and it is likely that R. macrocephala ornata Bronnimann, R. rugosa pennyi Bronnimann, R. badryi El-Naggar and R. browni El-Naggar are all assignable to R. rugosa (Pessagno 1967; Masters 1977; Swiecicki 1980 (unpubl.)). Swiecicki (1980 (unpubl.)) recorded the presence of transitional forms between Archaeoglobigerina cretacea (d'Orbigny 1841) and R. rugosa from the top of the Campanian thus giving strength to the idea that R. rugosa evolved directly from A. cretacea at this level.

Size: Diameter : 0.24mm
Thickness : 0.15mm

Distribution: this species has its highest occurrence within the Late Maastrichtian (Zone F.I.1) of all the studied wells and is recorded rarely to abundantly throughout the sections.

Superfamily NONIONACEA Schultze 1854
Family NONIONIDAE Schultze 1854
Subfamily NONIONINAE Schultze 1854
Genus PULLENIA Parker & Jones 1862
Type species Nonionina bulloides d'Orbigny 1846

Pullenia quaternaria (Reuss 1851)

(Pl.17, fig.1a,b)

1851 Nonionina quaternaria Reuss, p.34, pl.2, fig.13.

1928 Pullenia quinqueloba (Reuss); Franke, p.194, pl.18, fig.13.

1936b " quaternaria (Reuss); Cushman, p.74.

1951 " " (Reuss); Visser, p.283, pl.2, fig.21.

1957 " " (Reuss); Hofker, pp.430-431, t.fig.486.

1981 " " (Reuss); Hart et al., in Jenkins & Murray, p.216, pl.7.22, fig.3.

Description: test free and moderately compressed; planispirally coiled and involute; outline subcircular and weakly lobate with well rounded periphery; chambers triangular and slightly curved, increasing gradually in size as added with the final chamber covering the umbilicus on either side; four to five chambers in the final whorl; sutures distinct, flush to weakly compressed and slightly curved; aperture a low interiomarginal slit extending from umbilicus to umbilicus and bordered by a thick imperforate band; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the Upper Cretaceous of Lemberg (Reuss 1851) and is characterised by the moderately compressed test and the low apertural face.

Size: Diameter : 0.17mm
Thickness : 0.14mm

Distribution: rare specimens assignable to this species have been recorded sporadically from all the studied well sections, 'topping' within the Late Maastrichtian (Zone F.I.1).

Pullenia reussi Cushman & Todd 1943

(Pl.17, fig.2a,b)

1943b Pullenia reussi Cushman & Todd, pp.4-5, pl.1, figs.10-13.
1951 " " Cushman & Todd; Visser, p.284, pl.2, fig.22.
1953 " " Cushman & Todd; Hagn, p.91, pl.8, fig.19
1956 " " Cushman & Todd; Said & Kenawy, p.156, pl.7, fig.22.
1960 " " Cushman & Todd; Belford, p.90, pl.24, figs.19-21.

Description: test free and subspherical; planispirally coiled and involute; outline circular with very well rounded periphery; chambers triangular and slightly curved, increasing gradually and uniformly in size as added with the final chambers covering the umbilicus on either side; four to five chambers in the final whorl; sutures distinct, flush and very slightly curved; aperture a low interiomarginal slit extending from umbilicus to umbilicus; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the Upper Cretaceous of Mersch, near Hamm, Germany (Cushman & Todd 1943). It is very similar to P. quaternaria (Reuss) from which it may be distinguished by its smaller , spherical test, although juvenille specimens possess a slightly more compressed test (Swiecicki 1980 (unpubl.)).

Size: Diameter : 0.26mm

Thickness : 0.29mm

Distribution: this species has its highest occurrence within the Late Maastrichtian (Zone F.I.1) of well 49/20-2 and within the Early Maastrichtian (Zone F.I.2) of well 44/2-1 and is recorded rarely and sporadically from these sections.

Family OSANGULARIIDAE Loeblich & Tappan 1964

Genus OSANGULARIA Brotzen 1940

Type species Osangularia lens Brotzen 1940

Osangularia cordieriana (d'Orbigny 1840)

(Pl.17, fig.3a,b,c)

1840 Rotalina cordieriana d'Orbigny, p.33, pl.3, figs.9-11.

1941 Pulvinulinella cordieriana (d'Orbigny); Marie, p.228, pl.35, figs.329,330.

1945 Parrella cordieriana (d'Orbigny); Brotzen, pp.56-57.

1957 Osangularia cordieriana (d'Orbigny); Hofker, p.389, t.fig.433.

1961 Parrella cordieriana (d'Orbigny); Vasilenko, p.95, pl.15, figs.7,8, t.fig.14, nos.9,10.

1963 " sp. cf. cordieriana (d'Orbigny); Graham & Church, p.59, pl.7,fig.4.

1964 Osangularia sp. cf. cordieriana (d'Orbigny); McGugan, p.946, pl.152, fig.2.

1964 Osangularia cordieriana (d'Orbigny); Martin, p.102, pl.15, fig.2.

1968 " " (d'Orbigny); Sliter, p.118, pl.21, fig.9.

1972 " " (d'Orbigny); Hanzlikova, p.127, pl.36, fig.12

non 1977 " " (d'Orbigny); Sliter, pl.9, figs.1-3,6.

?1977 " whitei (Brotzen); Sliter, pl.9, figs.4,5.

1980 " cordieriana (d'Orbigny); Gawor-Biedowa, p.41, pl.6, figs.11,12.

1981 " " (d'Orbigny); Hart et al., in Jenkins & Murray, p.212, pl.7.20, figs.4-6.

Description: test free, biconvex and biumbonate with an acute and slightly carinate periphery; chambers arranged trochospirally in three to four whorls with eight to ten in the final whorl, increasing uniformily and gradually in size as added; umbilical side marked by a distinct, raised calcite boss; sutures distinct umbilically, straight to slightly curved and oblique, flush becoming slightly depressed between the final chambers; sutures initially obscure but becoming distinct, flush, oblique and curved spirally; aperture a narrow oblique slit along the base of the final chamber on the umbilical side then forming a 'V'-shaped bend at an oblique angle up the apertural face; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the Campanian of the Paris Basin (d'Orbigny 1840), and is characterised by the almost equally biconvex, biumbonate test and the slightly carinate margin. It is very similar to the closely related O. whitei (Brotzen 1936), but can be distinguished by the sigmoid periphery as compared to the horizontal periphery of O. whitei. It may be distinguished from O. navarroana (Cushman 1938) by the far less well developed peripherial keel. It is possible that these species are phylogenetically related (Swiecicki 1980 (unpubl.) t.fig. 5.3). The unequally biconvex form of Sliter (1977) referred to as O. cordieriana does not fall within the morphological variation of this species. The species Sliter (1977) assigns to O. whitei possesses a biconvex test and a distinct, raised, umbilical plug and was tentatively assigned to O. cordieriana by Swiecicki (1980 (unpubl.)).

Size: Diameter : 0.31mm

Height : 0.18 mm

Distribution: this species appears 'downhole' towards the base of the Early Maastrichtian (Zone F.I.2) of all three well sections and is recorded rarely to commonly throughout.

Osangularia navarroana (Cushman 1938)

(Pl.17, fig.4a,b,c)

1938 Pulvinulinella navarroana Cushman, p.66, pl.11, fig.5.

1946 " " Cushman; Cushman, p.144, pl.60, fig.1.

1954 Pseudoparrella navarroana (Cushman); Frizzell, p.126, pl.19, fig.9.

1957 Osangularia lens Brotzen; Hofker, p.390, t.fig.434.

1961 Parrella navarroana (Cushman); Vasilenko, p.97, pl.16, figs.1-3, t.fig.14, nos.11,12.

1962 Osangularia cordieriana navarroana (Cushman); Hermanni, p.280, pl.19, figs.2-4.

1977 " " " (Cushman); Koch, pp.60-61, pl.6, figs.6,7.

1977 Epistominella nana (Reuss); Villain, pp.61-62, pl.8, figs.1-3.

1981 Osangularia navarroana (Cushman); Hart et al., in Jenkins & Murray, p.212, pl.7.20, figs.7,8.

Description: test free and equally biconvex with an acute periphery bordered by a well developed keel; chambers arranged trochospirally in two and a half whorls with ten to twelve in the final whorl visible on umbilical side, increasing uniformly and gradually in size as added; umbilical side marked by a moderately raised calcite boss; sutures

distinct, limbate, flush, oblique and slightly curved; aperture a narrow 'V'-shaped slit, occasionally split into distinct interiomarginal and areal openings; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the Kemp Clay, Texas (Cushman 1938) and is characterised by the biconvex test and keeled margin.

The specimens figured and described as the Tertiary species Epistominella nana (Reuss) by Villain (1977) are probably conspecific with the present species.

Size: Diameter : 0.34mm
Height : 0.22mm

Distribution: rare to moderately common specimens referable to this species have been sporadically encountered, 'topping' within the Late Maastrichtian (Zone F.I.1) of all the studied sections.

Osangularia whitei (Brotzen 1936)

(Pl.18, fig.1a,b,c)

1936 Eponides whitei Brotzen, pp.167-169, pl.12, figs. 7,8.
1936 " " var. intercedens Brotzen, p.167, pl.12, fig.6.
1945 Parella whitei (Brozen); Brotzen, p.57.
pl961 " " var. whitei (Brozen); Vasilenko, p.91, pl.14, fig.5, fig. 14, no.1, non. 2.3.
?1977 Osangularia whitei (Brotzen); Sliter, pl.9, figs.4,5.
1981 " " (Brotzen); Hart et al., in Jenkins & Murray, p.212, pl.7.20, figs.9,10.

Description: test free, equally biconvex and biumbonate, with a subacute and slightly carinate periphery; chambers arranged trochospirally in three whorls with seven to eight in the final whorl, increasing uniformly and rapidly in size as added; umbilical side may possess a small, flush calcite boss; sutures moderately distinct, straight to slightly oblique and flush; aperture a narrow 'V' shaped slit, occasionally split into interiomarginal and areal openings with a very slightly raised lip; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the Santonian of Eriksdal, Sweden (Brotzen 1936) and can be distinguished from the closely related O. cordieriana (d'Orbigny) by its almost horizontal periphery.

Size: Diameter : 0.38mm
Height : 0.20mm

Distribution: within the Early Campanian interval (Zone F.I.5) of all the studied well sections, this species has its highest occurrence 'downhole' and is recorded rarely to abundantly throughout.

Genus GLOBOROTALITES Brotzen 1942
Type species Globorotalia multisepta Brotzen 1936

Globorotalites conicus (Carsey 1926)
(Pl.18, fig.2a,b)

1926 Truncatulina refulgens var. conica Carsey, p.46, pl.4, fig.15.
1931 Eponides micheliniana (d'Orbigny); Plummer, p.192, pl.14, fig.11.
1942 Globorotalites n.sp. Brotzen, p.31.

p1946 Globorotalia micheliniana (d.Orbigny); Cushman, p.152, pl.63, fig.3 (non.fig.2.).

1954 Globorotalites conicus (Carsey); Frizzell, p.130, pl.20, fig.31.

1956 " " (Carsey); Said & Kenawy, p.47, pl.4, fig.43.

1956a " multisepta (Brotzen); Hofker, p.B.210, fig.15.

non1957 " conicus (Carsey); McGugan, p.343, pl.34, figs.13, 14.

non1960 " " (Carsey); Belford, p.100, pl.30, figs.8-13.

non1965 " " (Carsey); Goel, pp.105-106, pl.2, figs. 3, 7.

1966 " multisepta (Brotzen); Hofker, p.27, pl.3, fig.55.

non1977 " conicus (Carsey); Sliter, p.19, figs.7,8.

Description: test free, plano-convex trochospire with flat to slightly concave spiral side and convex, moderately high and conical umbilical side with a broad, deep, pseudo-umbilicus; outline circular to lobate, periphery acute, carinate with imperforate keel; chambers distinct, angular, conical and slightly inflated with six to seven in the final whorl; sutures indistinct and flush, radiate to slightly sigmoid umbilically, oblique, straight to slightly curved spirally; aperture a narrow elongate interiomarginal slit along margin of final chamber; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the Campanian of Texas (Carsey 1926) and can be distinguished from the closely related G. micheliniana (d'Orbigny 1840) by its broad, deep pseudoumbilicus and the lower, wider form.

Size: Diameter : 0.37mm
Height : 0.33mm

Distribution: this species has been recorded only rarely and sporadically from wells 44/2-1 and 49/19-1, where it 'tops' within the Late Campanian (Zone F.I.3).

Globorotalites hiltermanni Kaever 1961
(Pl.18, fig.3a,b)

1946 Gyroidina micheliniana (d'Orbigny); Schijfsma, p.87, pl.5,fig.2.
1957 Globorotalites conicus (Carsey); McGugan, p.343, pl.34, figs.13,14.
1957 " multiseptus (Brotzen); Hofker, pp.408-409, t.figs. 467-469.
1961 " hiltermanni Kaever, p.418-419, pl.20, fig.1.
1965 " meudonensis Goel, pp.99-100, pl.1, fig.1.
pl972 " michelinianus (d'Orbigny); Hanzlikova, p.128, pl.33, fig.7, non fig.8.
1981 " hiltermanni Kaever; Hart et al., in Jenkins & Murray, p.198, pl.7.13, figs.10,11.

Description: test free, almost equally biconvex with acute, slightly keeled periphery, chambers arranged trochospirally in one and a half to two and a half whorls with seven to nine in the final whorl visible on the umbilical side, chambers indistinct, becoming slightly inflated umbilically; sutures indistinct, flush to weakly depressed; aperture a narrow, elongate interiomarginal slit with distinct murus reflectus; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the upper Late Campanian of Germany (Kaever 1961) and is characterised by the almost equally biconvex test and closed umbilicus.

Size: Diameter : 0.5mm
Height : 0.33mm

Distribution: rare specimens referable to this species have been recorded at the top of the Late Campanian interval (Zone F.I.3) of all the studied well sections. It is recorded only rarely and sporadically in the sections.

Globorotalites micheliniana (d'Orbigny 1840)
(Pl.18, fig.4a,b,c)

1840 Rotalina micheliniana d'Orbigny, pp.31-31, pl.3, figs.1-3.
1899 Rotalia " (d'Orbigny); Egger, p.155, pl.20, figs.1-3.
1941 Gyroidina micheliniana (d'Orbigny); Marie, p.222, pl.34, fig.323.
pl1946 Globorotalia micheliniana (d'Orbigny); Cushman, p.153, pl.63, fig.2, non fig.3.
1948 Globorotalites micheliniana (d'Orbigny); ten Dam & Magné, pp.223-224, t.fig.8a-c.
1957 " " (d'Orbigny); Hofker, p.405, t.figs.460-66
1961 " " (d'Orbigny); Kaever, pp.409-412, pl.18, fig.3, pl.19, fig.1, pl.20, fig.5, pl.21, figs.1,2.
1961 " " (d'Orbigny); Vasilenko, p.58, pl.10, figs.1,2.
1965 " " (d'Orbigny); Goel, p.100, pl.1, fig.2.

p1972 _____ " _____ " _____ (d'Orbigny); Hanzlikova, p.128, pl.37, fig.8, non fig.7.

1977 _____ " _____ " _____ (d'Orbigny); Villain, p.56, pl.9, figs.4-6.

1980 _____ " _____ micheliniana (d'Orbigny); Gawor-Biedowa, pp.41-42, pl.7, figs.7-9.

1981 _____ " _____ micheliniana (d'Orbigny); Hart et al., in Jenkins & Murray, p.200, pl.7.14, figs.1,2.

Description: test free, plano-convex trochospire with a flat spiral side and convex, moderately high and steeply conical umbilical side normally without a pseudoumbilicus; outline circular, periphery acute to subacute and slightly keeled; chambers indistinct, uninflated and conical with six to seven in the final whorl, sutures distinct, slightly depressed, radial and curved umbilically, indistinct, flush, curved and oblique spirally; aperture a narrow elongate interiomarginal slit, may be bordered by a slight lip; wall calcareous and finely perforate and surface smooth.

Remarks: this species was originally described from the Upper Cretaceous of the Paris Basin (St. Germain & Meudon) and England (d'Orbigny 1840). This species is highly variable with respect to the height of the pseudoumbilicus (if present), although little of this variation would appear to have any stratigraphic value (Goel 1965).

G. micheliniana may be distinguished from G. conicus (Carsey 1926) by the markedly higher, more conical outline, a less developed keel and lack of a wide, deep umbilicus.

Size: Diameter : 0.35mm
Height : 0.24mm

Distribution: this species has its highest occurrence within the Late Campanian (Zone F.I.3) of wells 44/2-1 and 49/20-2, and within the mid-Campanian (Zone F.I.4) of well 49/19-1. It is recorded rarely to moderately commonly throughout the studied well sections.

Genus GYROIDINOIDES Brotzen 1942

Type species Rotalia nitida Reuss 1844

Gyroidinoides nitida (Reuss 1844)

(Pl.19, fig.1a,b,c)

1844 Rotalia nitida Reuss, p.214.
1891 " umbilicata var. nitida (Reuss); Beissel, p.71, pl.14, figs.14-19.
1925 " soldani f. nitida (Reuss); Franke, p.89, pl.8, fig.3.
1934 Gyroidina nitida (Reuss); Morrow, p.197, pl.30, fig.1.
1941 " aff. nitida (Reuss); Marie, pp.220-221, pl.34, fig.319.
1941 " umbilicata (d'Orbigny); Marie, p.219, pl.34, fig.318.
1942 Gyroidinoides nitida (Reuss); Brotzen, p.19, figs.6,3.
1943 Gyroidina nitida (Reuss); Frizzel, p.351, pl.57, fig.6.
1946 " " (Reuss); Schijfsma, p.85, pl.5, fig.1.
1957 " umbilicata (d'Orbigny); McGugan, p.342, pl.33, fig.4.
1957 Gyroidinoides nitida (Reuss); Hofker, pp.393-395, t.figs.437-440,444.
?1957 " octocamerata Hofker, pp.396-399, t.figs.442, 443, 447-451.
1964 " nitida (Reuss); Loeblich & Tappan, p.C753, fig.615, no.6.

1966 ____" ____" (Reuss); Hofker, p.27, pl.3,fig.62, pl.11, figs.112-113.

?1966 ____" octocamerata Hofker; Hofker, p.40, pl.19, fig.44.

1968 ____" nitidus (Reuss); Sliter, p.121, pl.22, fig.7.

1972 ____" ____" (Reuss); Hanzlikova, p.129, pl.37, fig.9.

1973 ____" ____" (Reuss); Koch, p.212.

1977 ____" nitida (Reuss); Villain, pp.56-57, pl.10, figs.1-3.

1980 ____" nitidus (Reuss); Gawor-Biedowa, p.42, pl.8, figs.12,13.

Description: test free, spirally weakly convex to flat, umbilically strongly convex; outline circular, periphery broadly rounded; chambers arranged trochospirally in three to three and a half whorls, seven to eight chambers in the final whorl; sutures initially indistinct, flush, becoming distinct and depressed, straight to slightly curved spirally; umbilically sutures distinct, depressed close to the umbilicus and flush towards the periphery, straight and radial; aperture a narrow elongate slit along the inner margin of the final chamber, may be bordered by a thin lip; umbilicus small and open; wall calcareous, finely perforate, surface smooth.

Remarks: this species is highly variable but the subglobular form and narrow umbilical depression are characteristic.

Size: Diameter : 0.33mm
Height : 0.30mm

Distribution: this species appears 'downhole' within the Late Maastrichtian (Zone F.I.1) of all the studied well sections and is generally recorded rarely to moderately commonly throughout.

Family ANOMALINIDAE Cushman 1927

Genus ANGULOGAVELINELLA Hofker 1957

Type species Discorbina gracilis Marsson 1878

Angulogavelinella bettenstaedti Hofker 1957

(Pl.19, fig.2a,b,c)

1957 Angulogavelinella bettenstaedti Hofker, pp.367-368, t.figs.421-422.

1972 " " Hofker; Hanzlikova, p.130, pl.38, fig.6.

Description: test free, biconvex with umbilical side slightly more convex than spiral side; outline circular and acute, keeled periphery; chambers arranged trochospirally in two to three whorls with eight to ten in the final whorl increasing uniformly and regularly in size as added; chambers uninflated, oblique and crescentric; sutures distinct, raised, limbate and strongly curved umbilically, flush, limbate and curved spirally; aperture an high interiomarginal arch with a narrow lip extending along the spiral suture onto the umbilical side and partially covered by an umbilical chamber flap; wall calcareous, perforate umbilically, non perforate spirally, surface smooth.

Remarks: this species was originally described from the Upper Campanian and Lower Maastrichtian of N.W. Germany and Holland (Hofker 1957), and has since been recorded from the Lower Maastrichtian Sponge Beds at Sidestrand, Norfolk (Swiecicki 1980 (unpubl.)).

Size: Diameter : 0.33mm
Height : 0.19mm

Distribution: this species was recorded only rarely and sporadically, 'topping' within the Late Maastrichtian (Zone F.I.1) of well 49/20-2, within the Early Maastrichtian (Zone F.I.2) of well 44/2-1, and within the Late Campanian (Zone F.I.3) of well 49/19-1.

Genus CIBICIDOIDES Thalmann 1939

Type species Truncatulina mundula Brady, Parker & Jones 1888

Cibicidoides (?) voltziana (d'Orbigny 1840)

(Pl.19, fig.3a,b,c)

1840 Rotalina voltziana d'Orbigny, p.31, pl.2, figs.32-34.
1925 Truncatulina voltziana (d'Orbigny) f. consricta Hagenow; Franke, p.84, pl.7, fig.8.
1928 " constricta Hagenow; Franke, p.178, pl.16, fig.3.
?1928 " voltziana (d'Orbigny); Franke, p.177, pl.16, fig.7.
1934 Cibicides spiropunctatus Galloway & Morrey; Dain, p.48, pl.5, fig.53.
?1936 " padella Jennings, p.40, pl.5, fig.6.
1937 Planulina voltziana (d'Orbigny); Kalinin, p.56, pl.8, figs.118-120.
1940 Cibicides " (d'Orbigny); Brotzen, p.24, pl.7, fig.3.
1941 " " (d'Orbigny) f. typica Marie, pp.246-248, pl.37, figs.345-347.
1954 " (Cibicidoides) voltziana (d'Orbigny); Vasilenko, p.154, pl.25, figs.3,4.
1957 " voltziana (d'Orbigny); McGugan, p.344, pl.32, fig.23.

1957 Gavelinopsis voltziana (d'Orbigny); Hofker, pp.336-337, t.figs.367, 387,388,393.

1957 " ventricosa Hofker, pp.337-338, t.fig.389.

1961 Anomalina (Brotzenella) menneri Keller; Vasilenko, p.126, pl.24, fig.2, pl.27, fig.1.

?1964 " voltziana (d'Orbigny); McGugan, p.946, pl.152, pl.1.

1966 Gavelinopsis voltziana (d'Orbigny); Hofker, pp.29,42, pl.3, fig.63, pl.6, fig.56, pl.11, fig.124.

1977 " " (d'Orbigny); Villain, pp.59-60, pl.7, figs.4-6.

1981 Cibicidoides (?) voltziana (d'Orbigny); Hart et al., in Jenkins & Murray, pp.184-185, pl.7.6, figs.4-6.

Description: test free, plano-convex trochospire of three to four involute whorls; spiral side strongly convex with moderate to large calcite boss, umbilical side flat with or without a small, central, calcite boss; chambers indistinct and slightly inflated dorsally with nine to eleven in the final whorl, increasing gradually and uniformly in size as added; sutures distinct, curved and slightly depressed; aperture an interiomarginal, broad, low arch extending onto the umbilical surface; wall calcareous, surface smooth.

Remarks: this species was originally described by d'Orbigny from the Upper Campanian of the Paris Basin (Meudon, St. Germain) and England (1840). The figures of the holotype show a sharply angled form; specimens that have been recorded from the British Campanian are generally less acutely angled (Swiecicki 1980 (unpubl.)).

The characteristically large, plano-convex test with the prominent calcite bosses make this species distinctive although its generic position is unclear (Swiecicki 1980 (unpubl)); Hart et al. 1981). This

species has been referred to a variety of genera including Cibicides, Cibicidoides, Gavelinella and Gavelinopsis all of which display similarities in basic morphology but differ in their test wall structure. Unfortunately most foraminiferal tests from the Upper Chalk have undergone fine scale recrystallisation resulting in a secondary, heterogeneous granular wall structure (Reiss 1959; Schlanger & Douglas 1974). Thus, this species can only tentatively be assigned to the genus Cibicidoides; study of unrecrystallised material may prove this erroneous.

Gavelinopsis ventricosa Hofker 1957, was distinguished from C. (?) voltziana by its greater development of calcite bosses. The degree to which the calcite bosses develop is seen to be highly variable and is here not considered to be a valuable specific character. Therefore the two are considered conspecific.

This species reaches a maximum size in the Early Maastrichtian-Late Campanian interval in the boreholes from block 49 (Ball in press).

Size: Diameter : 0.82mm
Height : 0.5mm

Distribution: this species has its highest occurrence within the Late Maastrichtian (Zone F.I.1) of all the studied well sections, and is generally recorded rarely to moderately commonly throughout the sections.

Genus GAVELINELLA Brotzen 1942

Type species Discorbina pertusa Marsson 1878

Gavelinella baltica Brotzen 1942

(Pl.19, fig.4 a,b,c)

1942 Gavelinella baltica Brotzen, p.50, pl.1, fig.7.

1962 " " Brotzen; Jefferies, pl.78, fig.9a,c.

1962 " " Brotzen; Hiltermann & Koch, p.319, pl.47, fig.1.

1972 " (Gavelinella) baltica Brotzen; Gawor-Biedowa, pp.125-126, pl.17, fig.5a-c.

1977 " baltica Brotzen; Carter & Hart, p.46, pl.1, figs.36-38.

1980 " gr. baltica Brotzen; Robaszynski et al., p.278, pl.9, figs.10-17.

1981 " baltica Brotzen; Hart et al,. in Jenkins & Murray, p.192, pl.7.10, figs.3-5.

1982 " (Gavelinella) baltica Brotzen, Gawor-Biedowa, p.138, pl.21, fig.9, pl.22, fig.9.

Description: test free, low trochospire, biconvex with flattened sides; outline circular to weakly lobate, periphery rounded; chambers distinct, arranged in two to two and a half whorls, with eight to twelve in the final whorl; chambers slightly inflated, increasing uniformly and gradually in size as added until the last three to four which expand rapidly as added; sutures distinct and depressed; aperture a low interiomarginal slit extending from the periphery to the umbilicus; wall calcareous, surface smooth.

Remarks: this species is characterised by the rapidly expanding final three or four chambers which serve to distinguish it from Gavelinella intermedia (Berthelin).

Size: Diameter : 0.47mm
Height : 0.27mm

Distribution: this species appears "downhole" within the Late-Middle Cenomanian (Zone F.I.11) of the three wells studied and is recorded rarely throughout the sections.

Gavelinella bembix (Marsson 1878)
(Pl.20, fig.1a,b,c)

1878 Discorbina bembix Marsson, p.167, pl.5, fig.37.
1899 Rotalia bembix (Marsson); Egger, p.155, pl.20, fig.29.
1925 " " (Marsson); Franke, p.90, pl.8, fig.5.
?1941 Cibicides bembix (Marsson); Marie, p.248, pl.37, figs.350,351.
?1953 " " (Marsson); Hagn, p.101, pl.8, fig.22.
1954 " (Cibicidoides) bembix (Marsson); Vasilenko, p.155, pl.27, figs.3,4.
1956e Gavelinopsis bembix (Marsson); Hofker, p.101, fig.15.
1957 " " (Marsson); Hofker, pp.330-333, t.figs.383-384, ?t.figs.380-382.
1966 " " (Marsson); Hofker, p.42, pl.6, figs.58-59.
1969 " " (Marsson); Hanzlikova, p.36, pl.17, fig.2.
1972 " " (Marsson); Hanzlikova, pp.86-87, pl.20, fig.12.

Description: test free, small and plano-convex, umbilical side flat with a large, well developed, flattened calcite boss, spiral side highly convex, conical in shape with a distinct raised, clear, calcite boss; outline circular, periphery acute with an inperforate keel; chambers distinct and numerous, curved, arranged trochospirally with ten to twelve in the last whorl; sutures distinct, depressed and curved; aperture a low interiomarginal arch, bordered by an indistinct lip; wall calcareous and finely perforate, surface smooth.

Remarks: this species was originally described from the Maastrichtian of Rügen (Marsson 1878). There are marked similarities between this species and juvenilles of Cibicidoides (?) voltziana (d'Orbigny 1840), and some have regarded G. bembix as a juvenille stage (eg. Villain 1977). G. bembix may be distinguished by its smaller size, and more numerous chambers, and the low, broad umbilical boss. The latter two characteristics are not seen in the juvenille stages of C. (?) voltziana, and as the two species have different stratigraphic ranges, they must be regarded as quite separate species.

This species has been referred to a variety of genera including Cibicides, Gavelinella, Cibicidoides and Gavelinopsis. Members of these genera all show a basic morphologic similarity but differ in their wall structure. Before a definite generic assignment can be made a determination of the wall structure of this species is necessary. However, most foraminiferal tests from the Upper Chalk have undergone fine scale recrystallisation leaving a secondary heterogenous granular wall structure (eg. Reiss 1959; Schlanger & Douglas 1974). Thus, this species can only be tentatively assigned to the genus Gavelinella until the study of unrecrystallised material is possible.

Size: Diameter : 0.24mm
Height : 0.18mm

Distributon: rare to moderately common specimens assignable to this species are recorded from all the studied well sections, 'topping' within the Late Maastrichtian (Zone F.I.1).

Gavelinella clementiana clementiana (d'Orbigny 1840)

(Pl.20, fig.2a,b,c)

1840 Rosalina clementiana d'Orbigny, p.37, pl.3, figs.23-25.

non 1925 Anomalina clementiana (d'Orbigny); Franke, p.85, pl.7, fig.12.

non 1928 " " (d'Orbigny); Franke, p.179, pl.16, fig.9.

1941 Discorbis clementiana (d'Orbigny); f. typica Marie, p.213, pl.33, fig.312.

1941 " " (d'Orbigny) var. rugosa Marie, p.213, pl.33, figs.310-311.

1941 " " (d'Orbigny) var. costata Marie, p.214, pl.33, fig.313.

1946 " " (d'Orbigny); Schijfsma, pp.81-82, pl.4, fig.11.

non 1946 Anomalina clementiana (d'orbigny); Cushman, p.155, pl.63, figs.12,13.

1953 Gavelinella clementiana (d'Orbigny); Hagn, p.84, pl.7, fig.11.

1957 " " (d'Orbigny); Hofker, pp.294-297, t.figs.350-352.

non 1961 Anomalina (Pseudovalvulineria) clementiana var. clementiana (d'Orbigny); Vasilenko, p.121, pl.22, fig.5.

p1966 Gavelinella clementiana (d'Orbigny); Hofker, p.27, pl.3, fig.61, non fig.59

non 1977 " " (d'Orbigny); Koch, p.46, pl.2, figs.4-6.

1977 " " (d'Orbigny): Villain, p.58, pl.11, figs.7-9.

1981 " " clementiana (d'Orbigny); Edwards, p.394, pl.58, figs.3-5.

1981 " " (d'Orbigny); Hart et al., in Jenkins & Murray, p.194, pl.7.11, figs.1-3.

1981 " " (d'Orbigny); Gazdzicka, p.83, pl.22, figs.10-11.

Description: test free, low trochospire; outline circular to moderately lobate and periphery broadly rounded; flattened or weakly concave and evolute spirally, with earlier whorls obscured by ornament, weakly convex and involute umbilically with a small umbilical calcite boss; chambers distinct and uninflated, sometimes becoming inflated, curved, with eight to ten in the final whorl; sutures distinct, initially raised and thickened becoming depressed and curved spirally; initially rasied and curved with a distinct calcite node proximal to the umbilicus, becoming flush to slightly depressed umbilically; aperture a low interiomarginal slit bordered by a distinct lip, extending into the umbilicus and covered by subtriangular chamber flaps; wall calcareous and coarsely perforate umbilically.

Remarks: this species was originally described from the Upper Campanian of the Paris Basin and England (d'Orbigny 1840). The figure of the type specimen shows a small compressed form with continuous raised spiral side sutures - these were referred to the variety 'costata' by Marie (1941). However, the degree of development of the spiral side ornamentation seems to vary and specimens may be large and concave spirally with irregular spiral side sutures, or small and compressed; these were referred to the varieties 'typica' and 'rugosa' by Marie (1941). The smaller, compressed forms seem to be the statigraphically older forms (Swiecicki 1980 (unpubl.)).

This species is morphologically similar to Gavelinella cristata (Goel 1965) but may be distinguished by the flat to concave spiral side.

Size: Diameter : 0.57mm

Height : 0.35mm

Distribution: this species has its highest occurrence 'downhole' within the Late Campanian (Zone F.I.3) of well 49/20-2, and within the mid Campanian (Zone F.I.4) of wells 44/2-1 and 49/19-1. It is recorded as being rare to moderately common throughout the sections.

Gavelinella clementiana laevigata (Marie 1941)

(Pl.20, fig.3a,b,c)

1941 Discorbis clementiana (d'Orbigny) var. laevigata Marie, p.212, pl.33, fig.209.

1954 Anomalina (Pseudovalvulineria) clementiana (d'Orbigny) var. laevigata Marie; Vasilenko, p.92, pl.10, fig.2.

1961 " (") clementiana (d'Orbigny) var. laevigata (Marie); Vasilenko, p.121, pl.22, fig.5.

pl1966 Gavelinella clementiana (d'Orbigny); Hofker, p.27, pl.3, fig.59, non fig.61.

?1972 " laevigata (Marie); Hanzlikova, p.131, pl.39, fig.1.

1981 " clementiana laevigata (Marie); Edwards, p.396, pl.58, fig.6.

Description: test free, low trochospire, outline circular to lobate and periphery rounded; concave and evolute spirally, early whorls obscured; convex umbilically, involute with a narrow umbilicus completely covered by large, overlapping apertural flaps; chambers distinct, inflated with eight to ten in the final whorl; sutures distinct, oblique and depressed spirally; initially raised or flush umbilically, rapidly becoming depressed; aperture an interiomarginal

arch bordered by a distinct lip, extending from the periphery into the umbilicus; wall calcareous and coarsely perforate umbilically, surface smooth.

Remarks: this species was originally described from the Upper Campanian of the Paris Basin (Marie 1941). It may be distinguished from G. clementiana clementiana (d'Orbigny 1840) by its unornamented concave spiral side, the greater chamber inflation and well developed chamber flaps.

Size: Diameter : 0.80mm
Height : 0.58mm

Distribution: this species is recorded rarely and sporadically from all the studied well sections, 'topping' within the Late Campanian (Zone F.I.3).

Gavelinella cristata (Goel 1965)

(Pl.20, fig.4a,b,c)

1965 Pseudovalvulineria cristata Goel, p.134, pl.8, fig.1.
1965 " hofkeri Goel, p.138, pl.10, fig.2.
1970 Gavelinella cristata (Goel); Bignot & Assadian, pl.1, figs.4-6.
p1977 " clementiana (d'Orbigny); Koch, p.46, pl.2, figs.4-5, non fig.6.
1981 " cristata (Goel); Hart et al., in Jenkins & Murray, p.194, pl.7.11, figs.4-6.

Description: test free, low trochospire, outline circular and periphery broadly rounded; weakly convex and evolute spirally, early whorls indistinct and obscured by ornament; weakly convex umbilically, involute with an irregular umbilical calcite boss; chambers distinct, weakly inflated, nine to ten in the final whorl; sutures distinct,

raised and thickened, becoming flush or depressed; aperture a low interiomarginal slit bordered by a distinct lip, extending from the periphery towards the umbilicus and covered by distinct, sub-triangular chamber flaps; wall calcareous and coarsely perforate umbilically.

Remarks: this species was originally described from the Lower Campanian of the Paris Basin (Goel 1965). G. cristata can be distinguished from G. clementiana (d'Orbigny 1840) by its convex spiral side and stronger ornamentation.

Size: Diameter : 0.56mm
Height : 0.33mm

Distribution: 'topping' at the base of the mid Campanian (Zone F.I.4) in well 49/20-2, and within the Early Campanian (Zone F.I.5) of wells 44/2-1 and 49/19-1, this species is recorded rarely to moderately commonly in the studied well sections.

Gavelinella cenomanica (Brotzen 1942)

(Pl.21, fig.1a,b,c)

1942 Cibicidoides (Cibicides) cenomanica Brotzen, p.54, pl.2, fig.2a-c.

1954 Anomalina (Pseudovalvulineria) cenomanica (Brotzen) var. cenomanica Vasilenko, p.87, pl.9,fig.2.

1957 Gavelinopsis cenomanica (Brotzen); Hofker, p.321, t.fig.370.

1962 " " (Brotzen); Hiltermann & Koch, p.318, pl.48, fig.1.

1966 " " (Brotzen); Michael, p.436, pl.50, figs.16,17.

1972 Gavelinella (Gavelinella) cenomanica (Brotzen); Gawor-Biedowa, pp.126-128, pl.17, fig.4a-c.

1977 ___"___ cenomanica (Brotzen); Carter & Hart, pp.46-48, pl.1, figs.27,28.

1980 ___"___ gr. cenomanica (Brotzen); Robaszynski et al., p.278, pl.9, figs.6-9.

1981 ___"___ (Gavelinella) cenomanica (Brotzen); Gawor-Biedowa, p.138, pl.20, figs.4,5,6.

1981 ___"___ cenomanica (Brotzen); Hart et al., in Jenkins & Murray, p.192, pl.7.10, figs.9,10,11.

Description: test free, low trochospire, biconvex; outline circular and periphery rounded to subacute; chambers distinct, arranged in two to two and a half whorls with eight to ten in the final whorl, increasing gradually and uniformly in size as added; sutures distinct and slightly depressed; umbilicus narrow, marked by a distinct calcite rim around the central depression; aperture a low interiomarginal arch or slit, extending from the periphery to the umbilicus; wall calcareous, surface smooth.

Remarks: this species is characterised by the presence of the beaded, umbilical rim which serves to distinguish it from Gavelinella intermedia (Berthelin 1880). It is assigned to the genus Gavelinella on the basis of a double septal wall structure; this is in agreement with the generic description of Gavelinella.

Size: Diameter : 0.29mm
Height : 0.16mm

Distribution: this species first appears 'downhole' within the Late-Middle Cenomanian (Zone F.I.11) of wells 44/2-1 and 49/19-1, and within the Middle-Early Cenomanian (Zone F.I.12) of well 49/20-2. It is recorded only rarely to moderately commonly in the studied sections.

Gavelinella gp. intermedia (Berthelin 1880)

(Pl.21, fig.2a,b,c)

1880 Anomalina intermedia Berthelin, p.67, pl.4, fig.14a,b.

1898 " ammonoides Reuss; Chapman, p.3, pl.1, fig.4.

1942 Gavelinella intermedia (Berthelin); Brotzen, p.52, t.fig.18.

1954 " " (Berthelin); Bartenstein, p.49, pl.1, figs.21-28.

1954 Anomalina (Anomalina) suturalis Mjatliuk; Vasilenko, p.51, pl.1, fig.1.

1954 " (") hostaensis Morosowa; Vasilenko, p.52, pl.1, fig.3.

1954 " (") infracomplanata Mjatliuk; Vasilenko, p.53, pl.1, fig.4.

1957 Gavelinella intermedia (Berthelin); Hofker, pp.285-286, t.figs. 336-337.

1960 " " (Berthelin); Moullade, p.138, pl.2, figs. 15-17.

1960 " flandrini Moullade, p.137, pl.2, figs.10-14.

1965 " intermedia (Berthelin); Neagu, p.32, pl.8, figs.1,2.

1972 " (Berthelina) intermedia (Berthelin); Gawor-Biedowa, pp.120-122, pl.15, figs.7-9, t.fig.12.

1977 " intermedia (Berthelin); Carter & Hart, p.48, pl.1, figs.33-35.

1977 " " (Berthelin); Price, p.516, pl.60, figs.7,8.

1981 " (Berthelina) intermedia (Berthelin); Gawor-Biedowa, pp.137-138, pl.20, figs.1,2,3.

1981 " intermedia (Berthelin); Hart et al., in Jenkins & Murray, p.194, pl.7.11, figs.7-9.

1982 " ex.gr. intermedia (Berthelin); Crittenden, p.31, pl.2, fig.8.

Description: test free, low trochospire; outline circular and periphery rounded, occasionally subacute; semi-involute spirally with one and a half to two whorls visible; chambers distinct, ten to twelve in the final whorl, increasing gradually and uniformly in size as added; sutures distinct, depressed or slightly raised; aperture an interiomarginal-equatorial slit bordered by a wide lip; wall calcareous, surface smooth.

Remarks: this species was originally described from the Gault Clay of Montcley (Berthelin 1880). It is an extremely variable species and has a confused taxonomic history (Price 1977).

Size: Diameter : 0.31mm
Height : 0.17mm

Distribution: this species is first recorded 'downhole' in the Late-Middle Cenomanian (Zone F.I.11) of wells 44/2-1 and 49/19-1, and within the Middle-Early Cenomanian (Zone F.I.12) of well 49/20-2. It is recorded rarely to moderately commonly in the studied sections.

Gavelinella lorneiana (d'Orbigny 1840)

(Pl.21, fig.3a,b,c)

1840 Rosalina lorneiana d'Orbigny, p.36, pl.3, figs.20-22.
1899 Anomalina " (d'Orbigny); Egger, p.152, pl.18, figs.7,8.
1925 " clementiana (d'Orbigny); Franke, p.85, pl.7, fig.12.
1928 " " (d'Orbigny); Franke, p.179, pl.16, fig.9.
non1928 " lorneiana (d'Orbigny); Franke, p.181, pl.17, fig.3.
non1936 " " (d'Orbigny); Brotzen, p.178, pl.12, figs.1,2.
1941 Discorbis " (d'Orbigny) f. typica Marie, p.216, pl.33, fig.314.

1941 ___"___"___ (d'Orbigny) var. costulata Marie, p.216, pl.34, fig.315.

p1946 Anomalina clementiana (d'Orbigny); Cushman, p.155, pl.63, fig.13, non fig.12.

1953 Pseudovalvulineria lorneiana (d'Orbigny); Hagn, p.82, pl.7, fig.12.

1964 Gavelinella lorneiana (d'Orbigny); Loeblich & Tappan, p.C759, fig.621, no.6.

non1966 ___"___"___ (d'Orbigny); Hofker, p.41, pl.16, fig.57, pl.18, fig.36.

1977 ___"___"___ (d'Orbigny var). "à ombic étroit" Villain, p.58, pl.11, figs.4-6.

1981 ___"___"___ (d'Orbigny); Edwards, pp.396-397, pl.56, figs.1-5.

1981 ___"___"___ (d'Orbigny); Hart et al., in Jenkins & Murray, p.194, pl.7.11, figs.10-12.

Description: test free, low trochospire, outline circular to slightly lobate and periphery broadly rounded to subacute, occasionally marked by a imperforate peripheral band; flat to weakly concave and partially evolute spirally, convex, involute with a narrow umbilicus umbilically; chambers distinct and weakly inflated increasing gradually and uniformly in size as added; two and a half to three whorls, with eight to ten chambers in the final whorl; sutures depressed; aperture a low interiomarginal slit bordered by an indistinct lip, extending into the umbilicus where it is covered by sub-triangular, imperforate chamber flaps; wall calcareous and coarsely perforate, surface smooth.

Remarks: this species was originally described (d'Orbigny 1840) from the Upper Campanian of the Paris Basin (St. Germain & Meudon). The illustration of the holotype lacks the characteristic well developed

chamber flaps and narrow umbilicus, leading to much taxonomic confusion; the erection of a lectotype by Loeblich & Tappan (1964) has since clarified the situation.

Size: Diameter : 0.44mm
Height : 0.19mm

Distribution: this species is recorded rarely to moderately commonly from all the studied well sections, 'topping' within the Late Campanian (Zone F.I.3) of well 44/2-1, and within the mid Campanian (Zone F.I.4) of wells 49/19-1 and 49/20-2.

Gavelinella monterelensis (Marie 1941)

(Pl.21, fig.4a,b,c)

1941 Anomalina monterelensis Marie, p.243, pl.37, fig.342.
non1946 " " Marie; Schijfsma, p.100, pl.6, fig.5.
1954 " (Pseudovalvulineria) monterelensis Marie; Vasilenko, p.108, pl.16, figs.5,6.
1956a Gavelinopsis menneri (Keller); Hofker, p.B210, fig.16.
1957 " " (Keller); Hofker, pp.333-334, t.figs.385-386.
1958 Anomalina (Brotzenella) monterelensis (Marie); Vasilenko in Bykova et al., p.52.
1964 Gavelinella monterelensis (Marie); Loeblich & Tappan, p.C759, fig.621, no.7.
1966 Gavelinopsis monterelensis (Marie); Hofker, p.29, pl.3, fig.60.
1972 Gavelinella monterelensis (Marie); Hanzlikova, p.131, pl.39, fig.3.
1977 Gavelinopsis monterelensis (Marie); Villain, p.59, pl.7, figs.1-3.
1981 Gavelinella monterelensis (Marie); Edwards, p.397, pl.58, figs.15-17.

1981 " " (Marie); Hart et al., in Jenkins & Murray, p.196, pl.7.12, figs.1-3.

Description: test free, biconvex and biumbate, umbilical boss distinct, raised and moderately large, spiral boss distinct, broad and low; outline circular to weakly lobate, periphery acute to subacute with an indistinct imperforate keel; chambers numerous, arranged trochospirally in two and a half to three whorls with twelve to fourteen chambers in the final whorl; chambers strongly curved, becoming distinctly inflated; sutures distinct, limbate and depressed; aperture a moderately high interiomarginal arch bordered by a thin lip, extending along the spiral suture into the umbilicus and partially covered by backward pointing chamber flaps; wall calcareous and finely perforate, surface smooth.

Remarks: this distinct and stratigraphically useful species was originally described from the Upper Campanian of the Paris Basin (Marie 1941).

G. monterelensis was placed in the genus Gavelinella on the basis of its biconvex test and subtriangular chamber flaps (Loeblich & Tappan 1964).

Size: Diameter : 0.52mm
Height : 0.23mm

Distribution: 'topping' within the Late Campanian (Zone F.I.3) of all the studied wells, this species was recorded rarely to moderately commonly throughout the sections.

Gavelinella pertusa (Marsson 1878)

(Pl.22, fig.1a,b,c)

1878 Discorbina pertusa Marsson, p.166, pl.4, fig.35.

1891 Rosalina ammonoides Reuss; Beissel, p.75, pl.16, figs.1-5.

1925 Anomalina pertusa (Márssón); Franke, p.86, pl.7, fig.16.

1940 Anomalina (?) pertusa (Marsson); Brotzen, p.29.

1941 Discorbis lorneiana (d'Orbigny) var. pertusa (Marsson); Marie, p.217, pl.34, fig.316.

1942 Gavelinella pertusa (Marsson); Brotzen, pp.41-43, pl.1, figs,1,2, t.fig.1.

p1946 Anomalina ammonoides (Reuss); Cushman, p.154, pl.63, fig.11, non fig.10.

1948 Gavelinella pertusa (Marsson); Brotzen, pp.75-76, figs.4-6, t.fig.20.

?1951 " " (Marsson); Visser, p.226, pl.5, fig.7.

1956a " " maastrichtensis Hofker, p.B216, fig.34.

1957 " " (Marsson); Hofker, p.291-292, t.figs.345-346.

1957 " " var. maastrichtensis Hofker, p.293-294, t.figs.347-348.

1964 " " (Marsson); Loeblich & Tappan, p.C759, fig.621, no.5.

1966 " " (Marsson); Hofker, p.27, pl.3, fig.57, pl.6, fig.60.

non1977 " " (Marsson); Villain, p.57, pl.10, figs.10-12.

1977 " lorneiana (d'Orbigny) "à omblic large" Villain, p.58, pl.11, figs.1-3.

1981 " pertusa (Marsson); Edwards, pp.397-398, pl.56, figs.7-9.

1981 " " (Marsson); Hart et al., in Jenkins & Murray, p.196, pl.7.12, figs.4-6.

Description: test free, low trochospire, outline circular to slightly lobate and periphery rounded to subacute; spirally flat to weakly convex and partially evolute and umbilically convex and involute with a wide, deep umbilicus; chambers distinct, weakly inflated, arranged trochospirally in two and a half to three whorls, nine to twelve in the final whorl, increasing gradually in size as added; sutures indistinct, flush to slightly depressed and radial; aperture an interiomarginal slit bordered by a distinct lip and extending into the umbilicus; wall calcareous and coarsely perforate, surface smooth.

Remarks this species was originally described from the Lower Maastrichtian of Rügen (Marsson 1878) and is characterised by the broad, open umbilicus.

Size: Diameter : 0.31mm
Height : 0.16mm

Distribution: rare to common specimens assignable to this species were recorded from all the studied well sections, having their highest occurrence within the Late Maastrichtian (Zone F.I.1).

Gavelinella stelligera (Marie 1941)
(Pl.22, fig.2a,b,c)

1941 Planulina stelligera Marie, p.245, pl.37, fig.344.
non1951 Gavelinella stelligera (Marie); Visser, p.267, pl.8, fig.10.
1953 " " (Marie); Hagn, p.82, pl.7, fig.13.
1981 " " (Marie); Edwards, p.404, pl.58, figs.12-14.

1981 " " (Marie); Hart et al., in Jenkins & Murray, p.196, pl.7.12, figs.10-12.

Description: test free and compressed, low trochospire of two and a half to three whorls, outline circular and periphery rounded to subacute; umbilical side with a broad shallow depression around the umbilicus filled by chamber flaps; chambers distinct and uninflated, curved, with twelve to thirteen in the final whorl, increasing gradually and uniformly in size as added; spirally chamber margins imperforate and thickened anterior to the sutures and appearing like oblique, curved ribs; sutures indistinct, curved and flush; aperture a narrow interiomarginal slit bordered by an indistinct lip; wall calcareous and coarsely perforate umbilically, surface smooth.

Remarks: this species was originally described from the Upper Campanian of the Paris Basin (Marie 1941) and is characterised by the broad, curved, imperforate ribs and compressed test. The form described by Visser (1951) as G. stelligera from the Maastrichtian of the Netherlands, was re-examined by Hofker (1966) and reassigned to G. simplex (Brotzen 1948).

Size: Diameter : 0.32mm
Height : 0.14mm

Distribution: this species has its highest occurrence in the mid-Campanian (Zone F.I.4) of all the studied wells and is recorded rarely to moderately commonly in the recovered microfaunas.

Gavelinella thalmanni (Brotzen 1936)

(Pl.22, fig.3a,b,c)

1936 Cibicides thalmanni Brotzen, pp.190-191, pl.14, fig.7.

1956 Anomalina (Gavelinella) sculptilis Hiltermann & Koch, p.38, t.fig.6, pl.3, fig.3.

non1957 Gavelinella clementiana (d'Orbigny) var. thalmanni (Brotzen); Hofker, pp.295-296, t.fig.358.

1961 Anomalina (Pseudovalvulineria) thalmanni (Brotzen); Vasilenko, p.119, pl.22, figs.2,3.

1962 Gavelinella sculptilis Hiltermann & Koch, p.319, pl.48, fig.2.

1966b " thalmanni (Brotzen); Barr, pp.506-507, pl.48, fig.1.

1973 " " (Brotzen); Koch, p.213.

1977 " " (Brotzen); Koch, p.41, pl.2, figs.1-3.

1981 " " (Brotzen); Edwards, p.404, pl.58, figs.7-11.

1981 " " (Brotzen); Hart et al., in Jenkins & Murray, p.198, pl.7.13, figs.1-3.

Description: test free, almost planispiral trochospire of two and a half to three whorls; umbilical side flat to slightly concave, involute with a narrow, shallow umbilicus partly covered by imperforate chamber flaps, spiral side concave, evolute, with a moderately deep, wide, depression exposing the previous whorl; outline circular and periphery rounded; chambers numerous and distinct, uninflated, with eleven to twelve in the final whorl, uniformly and gradually increasing in size as added; sutures indistinct, flush, straight and radial; aperture an interiomarginal slit extending from the periphery into the umbilical

area of the ventral side; wall calcareous and coarsely perforate, surface smooth ventrally but dorsally marked by raised rugose ribs anterior to the sutures, producing an irregular nodose ornament.

Remarks: this species was originally described from the Santonian of southern Sweden (Brotzen 1936), and has since been recorded as ranging from the Coniacian to the Lower Campanian (eg. Koch 1977; Hart et al. 1981). It can easily be distinguished from other members of the genus by the flattened ventral side and the wide, shallow umbilicus on the dorsal side.

Size: Diameter : 0.33mm
Height : 0.18mm

Distribution: 'topping' within the mid-Campanian (Zone F.I.4) of all the studied sections, this species is recorded rarely and sporadically throughout the wells.

Gavelinella cf. tourainensis (Butt 1966)
(Pl.22, fig.4a,b,c)

1966 Gavelinella tourainensis Butt, p.176, pl.4, figs.1-3.
1978 Gavelinella sp. B Bailey (unpubl.), p.202, pl.13, figs.10-12.

Description: test free, biconvex, low trochospire; outline circular to slightly lobate and periphery rounded to subacute; spiral side marked by a large, well developed, calcite boss dominating the central part of the test; chambers increasing uniformally and gradually in size as added, seven to eight in the final whorl; sutures distinct, curved, radial and slightly depressed; aperture an elongate slit following the spiral suture to the periphery; wall calcareous, surface smooth.

Remarks: this species appears to be very closely related to Gavelinella tourainensis (Butt 1966) described from the type Turonian and is the form referred to as Gavelinella sp. B by Bailey (1978 (unpubl.)). It probably represents a late example of the lineage G. reussi (Khan) - G. berthelini (Keller) - G. tourainensis (Butt), all characterised by a large, central, umbilical boss.

Size: Diameter : 0.30mm
Height : 0.22mm

Distribution: very rarely recorded from the wells studied, this species 'tops' within the Coniacian (Zone F.I.8) of well 44/2-1, and within the Late Turonian (Zone F.I.9) of well 49/20-2.

Gavelinella tourainensis (Butt 1966)
(Pl.23, fig.1a,b,c)

1966 Gavelinopsis tourainensis Butt, p.176, pl.4, figs.1-3.
?1982 Gavelinella (Berthelina) belorussica (Akimez); Gawor-Biedowa, p.76, pl.21, figs.1-3.

Description: test free, planoconvex to biconvex; outline circular to slightly lobate, periphery subacute; strongly convex spirally, evolute, with earlier whorls obscured by a central calcite boss; involute and flat umbilically, with a small central calcite boss; chambers indistinct becoming distinct, weakly inflated, increasing uniformly and gradually in size as added; sutures distinct, depressed and curved; aperture an interiomarginal slit extending along the spiral suture; wall calcareous, surface smooth.

Remarks: this species was originally described from the Fretevou Chalk of the type Turonian (Butt 1966). Because of recrystallisation of foraminiferal tests from the Upper Chalk resulting in a secondary,

heterogeneous granular wall structure (Reiss 1959; Schlanger & Douglas 1974), the exact generic position of this species is unclear (see remarks section under Cibicidoides (?) voltziana (d'Orbigny)). Therefore, the species is only tentatively assigned to the genus Gavelinella, but the study of unrecrystallised material may prove this to be erroneous.

Size: Diameter : 0.27mm
Height : 0.17mm

Distribution: rare specimens referable to this species were recorded sporadically from all the wells, 'topping' within the Late Turonian (Zone F.I.9) of well 44/2-1, and within the Early Turonian (Zone F.I.10) of wells 49/19-1 and 49/20-2.

Gavelinella tumida Brotzen 1942

(Pl.23, fig.2a,b,c)

1936 Anomalina lorneiana (d'Orbigny); Brotzen, p.178, pl.12, figs.1,2.
1942 Gavelinella tumida Brotzen, pp.47-48, fig.15.
1970 " " Brotzen; Porthault in Donze et al., p.59, pl.8, figs.13-15.
1973 " " Brotzen; Norling in Bergstrom et al., p.112, pl.8, figs.2,3.

Description: test free, low trochospire, outline circular and periphery broadly rounded; flattened spirally, slightly convex and involute umbilically, with a deep umbilicus; chambers distinct, inflated, increasing rapidly in size as added with the last two or three very inflated; sutures distinct, straight and radial, becoming depressed

where the chambers are inflated; aperture a low, interiomarginal slit, extending into the umbilicus; wall calcareous and perforate, surface smooth.

Remarks: this species was originally decribed from the Lower Senonian of Eriksdal, Sweden (Brotzen 1936; 1942), and has since been recorded from the Upper Coniacian to Lower Santonian of southern France (Porthault 1970), the Isle of Wight and S.E. Kent (Bailey 1978 (unpubl.)).

Size: Diameter : 0.35mm
Height : 0.25mm

Distribution: rare specimens assignable to this species were recorded sporadically from wells 44/2-1 and 49/20-2, 'topping' within the Coniacian (Zone F.I.8). This species was recorded from only one sample (2,660'-2,670') within the Early Turonian (Zone F.I.10) of well 49/19-1.

Gavelinella usakensis (Vasilenko 1961)

(Pl.23, fig.3a,b,c)

1961 Anomalina (Pseudovalvulineria) clementiana (d'Orbigny) var. usakensis Vasilenko, p.122, pl.23, fig.1.

?1965 Pseudouvalvulineria glabra Goel, pp.138-139, pl.9, fig.1.

pl977 Gavelinella clementiana (d'Orbigny); Koch, p.46, pl.2, fig.6, non figs.4,5.

1981 " usakensis (Vasilenko); Hart et al., in Jenkins & Murray, p.198, pl.7.13, figs.4-6.

Description: test free, low to moderate trochospire, outline circular to slightly lobate and periphery rounded; moderately convex spirally, evolute with earlier whorls obscured by a thickened calcite layer; weakly convex umbilically, involute with a small umbilical calcite boss; chambers distinct, uninflated becoming weakly inflated, slightly curved, nine to ten in the final whorl increasing uniformly and gradually in size as added; sutures flush to depressed and curved spirally; distinct, flush to slightly raised becoming depressed umbilically; aperture a low interiomarginal slit bordered by a distinct lip extending from the periphery to the umbilicus; wall calcareous and coarsely perforate umbilically.

Remarks: this species was originally described from the Campanian of southern Russia (Vasilenko 1961) and can be distinguished by the low to moderately convex, smooth spiral side.

Size: Diameter : 0.58mm
Height : 0.31mm

Distribution: this species was recorded rarely and sporadically from wells 44/2-1 and 49/20-2, 'topping' within the mid-Campanian (Zone F.I.4) in the former, and in the Late Campanian (Zone F.I.3) in the latter.

Genus LINGULOGAVELINELLA Malapris 1965

Type species Lingulogavelinella albiensis Malapris 1965

Lingulogavelinella globosa (Brotzen 1945)

(Pl.23, fig.4a,b,c)

1945 Anomalinoides globosa Brotzen, p.58, pl.2, fig.6a-c.

1962 " " Brotzen; Jefferies, p.78, fig.19a-c.

1966 Orostella turonica Butt, p.180, pl.3, fig.6, pl.4, fig.4.

1972 Lingulogavelinella globosa (Brotzen); Gawor-Biedowa, pp.107-108, pl.15, figs.4a-c, 5a-c.

1977 " " (Brotzen); Carter & Hart,p.49, pl.1, figs.12-14.

1980 " aff. turonica (Butt); Robaszynski et al., p.278, pl.9, figs.21-22.

1981 " globosa (Brotzen); Hart et al., in Jenkins & Murray, p.208, pl.7.18, figs.8-10.

1982 " " (Brotzen); Gawor-Biedowa, p.137, pl.17, figs.1,2.

Description: test free, low trochospire and equally biconvex; outline lobate and periphery rounded; centrally depressed spirally; chambers distinct and inflated, arranged in two to two and a half whorls with six to eight in the final whorl, increasing gradually and uniformly in size as added; sutures distinct, depressed and curved; aperture an interiomarginal slit bordered by a lip with remnant lips of older chambers producing a star-shaped pattern around the umbilicus; wall calcareous, surface smooth.

Remarks: the 'star-shaped' pattern around the umbilicus makes this a distinctive species. This is the stratigraphically youngest form of the Albian-Cenomanian 'lingulogavelinellid' lineage.

Size: Diameter : 0.24mm

Height : 0.18mm

Distribution: 'topping' within the Early Turonian (Zone F.I.10) of all the studied wells, this species is recorded rarely and sporadically within the well sections.

Lingulogavelinella sp. cf. L. vombensis (Brotzen 1945)

(Pl.24, fig.1a,b,c)

1928 Rotalina beccariformis White n.sp., var. White, pp. 287-288, pl.39, figs.3,4.

1945 Pseudovalvulineria vombensis Brotzen, p.5.

1975 Gavelinella aff. vombensis 2 (Brotzen); Robaszynski in Colbeaux et al., p.19, fig.2.

1978 Lingulogavelinella sp.A Bailey (unpubl.), pp.203-204, pl.14, figs.1-3.

1981 Lingulogavelinella sp. cf. L. vombensis (Brotzen); Hart et al., in Jenkins & Murray, p.210, pl.7.19, figs.1-3.

Description: test free, low trochospire; outline circular to weakly lobate and periphery rounded to subacute; spiral side marked by a well developed calcite boss, obscuring earlier whorls; involute umbilically; sutures distinct, flush to slightly depressed spirally, raised into low septal ridges umbilically; aperture a narrow interiomarginal slit covered by an aperture flap on the umbilical side, umbilicus filled by remnant apertural flaps producing a radiate pattern; wall calcareous, surface smooth between septal ridges.

Remarks: after examining material illustrated as Gavelinella aff. vombensis (Brotzen 1945) by Robaszynski (1975), Bailey (1978 (unpubl.)) concluded that it and his form Lingulogavelinella sp. A were

con-specific. This form, also recorded in the present study, seems to be the ancestral form of Brotzens original Maastrichtian species L. vombensis. L.vombensis does not appear to be an extension of the range of the present species (here referred to as L. sp. cf. L. vombensis).

Size: Diameter : 0.38mm
Height : 0.23mm

Distribution: recorded rarely and occasionally moderately commonly, this species 'tops' within the Coniacian (Zone F.I.8) of wells 44/2-1 and 49/19-1, and within the Late Turonian (Zone F.I.9) of well 49/20-2.

Genus STENSIOEINA Brotzen 1936

Type species Rotalia exsculpta Reuss 1860

Stensioeina exsculpta exsculpta (Reuss 1860)

(Pl.24, fig.2a,b,c)

1860 Rotalia exsculpta Reuss, p.78, pl.11, fig.4.
1936 Stensioeina exsculpta (Reuss); Brotzen, pp.165-166, pl.11, fig.8.
1942 " " (Reuss); Brotzen, p.20, fig.6,8.
1948 " " (Reuss); Williams-Mitchell, p.104, pl.9, fig.10.
1954 " " (Reuss); Pozaryska, p.264, fig.22A-C.
1957 " " (Reuss); McGugan, pp.341-342, pl.33, fig.3.
1961 " " (Reuss); Vasilenko, pp.65-66, pl.11, fig.4a,b.
1962 " " gracilis Brotzen; Hiltermann & Koch, p.324, pl.49, figs.13,14.

1968 " " exsculpta (Reuss); Trumper, pp.25-26, pl.8, figs.1-4, pl.9, fig.1a-c.

p1970 " praeexsculpta (Keller); Porthault in Donze et al., pp.59-60, pl.1, figs.6-9.

1981 " exsculpta exsculpta (Reuss); Hart et al., in Jenkins & Murray, p.218, pl.7.23, figs.11-13.

Description: test free, low trochospire, plano-convex to biconvex; outline circular and periphery acutely angled; involute on umbilical side, evolute with two and a half whorls visible on the spiral side; chambers distinct and subrectangular, increasing uniformly and gradually in size as added; sutures distinct, raised into distinct septal ridges on the spiral side, flush to slightly depressed on the umbilical side; aperture an elongate slit extending along the inner, ventral margin of the final chamber; wall calcareous, surface ornamented spirally, coarsely perforate umbilically.

Remarks: this subspecies can be distinguished from the 'Stensioeina granulata (Olbertz) lineage' by its angled periphery and ornamented spiral surface.

Size: Diameter : 0.41mm
Thickness : 0.18mm

Distribution: this species first appears 'downhole' at the top of the Late Santonian (Zone F.I.6) of all the studied wells, and is recorded rarely to abundantly throughout the studied sections.

Stensioeina exsculpta gracilis Brotzen 1945

(Pl.24, fig.3a,b,c)

1945 Stensioeina exsculpta var. gracilis Brotzen, p.52, pl.1, fig.15.

non1957 " gracilis (Brotzen); Hofker, p.347, t.figs.396-397.

1957 " exsculpta var. aspera Hofker, pp.349-350, t.figs.401-3.

1957 " " var. " mut. infirma Hofker, pp.350-351, t.fig.404.

1958 " " gracilis Brotzen; Pokorny, p.307, t.figs.13,14.

non1962 " " " Brotzen; Hiltermann & Koch, p.324, pl.49, figs.13,14.

1962 " " (Reuss); Hiltermann & Koch, p.325, pl.49, figs.15-18.

1968 " " gracilis Brotzen; Trumper, p.26, pl.9, fig.2, pl.10, figs.1-3, pl.11, figs.1,2,5, pl.12, figs.9,10.

1970 " gracilis Brotzen; Porthault in Donze et al., p.60, pl.8, figs.20,21.

1972 " exsculpta gracilis Brotzen; Hanzlikova, p.135, pl.40, figs.3-5.

1977 " " " Brotzen; Koch, p.44, pl.11, figs.5-8.

1981 " " " Brotzen; Gazdzicka, p.83, pl.22, fig.9.

1981 " " " Brotzen; Hart et al., in Jenkins & Murray, p.220, pl.7.24, figs.1-3.

Description: test free, low trochospire and biconvex; outline circular to weakly lobate and periphery acutely angled; moderately to highly convex and evolute spirally, with two and a half to three whorls visible; weakly convex and involute umbilically; chambers distinct and curved, uninflated becoming weakly inflated with ten to twelve in the final whorl, increasing uniformly and gradually in size as added; sutures distinct, strongly raised into a reticulate network with the spiral suture on the spiral side; radial and depressed on the umbilical side; aperture a low, interiomarginal opening bordered by a distinct lip; wall calcareous, coarsely perforate, surface smooth umbilically, covered with a fine nodose ornament between the sutures spirally.

Remarks: this subspecies was originally described from the Santonian of Höllviken and is characterised by the raised trochospiral coil and keeled margins.

Size: Diameter : 0.4mm
Thickness : 0.18mm

Distribution: this species has its highest occurrence at the top of the mid-Campanian (Zone F.I.4) in all the studied wells and is recorded rarely to abundantly in the sections.

Stensioeina granulata granulata (Olbertz 1942)

(Pl.25, fig.1a,b,c)

1935 Gyroidina praeexsculpta Keller, pl.3, figs.28-32.

1942 Rotalina exsculpta granulata Olbertz, pp.132-133, pl.5, fig.2.

1945 Stensioeina prae-exsculpta (Keller); Brotzen, pp.52-53, pl.1, figs.16,17.

1954 " praeexsculpta (Keller); Pozaryska, p.265, fig.23.

1956 " " (Keller); Hiltermann & Koch, tab.3, pl.1, fig.7.

1957 " prae-exsculpta (Keller); Hofker, p.345, figs.394,395.

1957 " " var. granulata (Olbertz); Hofker, pp.345-347, figs.394,395.

1962 " " (Keller); Hiltermann & Koch, p323, pl.49, figs. 10,11.

1962 " exsculpta granulata (Olbertz); Hiltermann & Koch, pp.323-324, pl.51, figs.1,2.

1966 " praeexsculpta (Keller); Salaj & Samuel, pp.147-148, pl.32, fig.1a,b.

1968 " granulata (Olbertz); Trümper, pp.10-14, pl.12, figs.1-3.

1970 " aff. granulata (Olbertz); Porthault, in Donze et al., pp.60-61, pl.8, figs.22,23.

1979 " granulata granulata (Olbertz); Bailey & Hart, p.161.

1981 " " " (Olbertz); Hart et al., in Jenkins & Murray, p.220, pl.7.24, figs.4-6.

Description: test free, low trochospire, plano-convex; outline circular and periphery rounded; flat and involute on umbilical side, evolute and convex on the spiral side; chambers distinct on spiral side only, with nine to ten in the final whorl, increasing uniformly and gradually in size as added; sutures distinct, straight and radial and raised into broad septal ridges on the spiral side; indistinct on the umbilical side; aperture a narrow interiomarginal slit along the vertical edge ofthe final chamber; wall calcareous, surface perforate umbilically and granular between the septal ridges spirally.

Remarks: following the work of Trümper (1968), Bailey (1978 unpubl) and Hart et al. (1981) consider S. granulata granulata to be conspecific with S. prae-exsculpta (Keller 1935). The importance of the first appearance (up section) of this subspecies in the British succession has been discussed by Bailey (1978 (unpubl.) and Bailey & Hart (1979) but this is not applicable in the present study because of the problems with ditch cuttings.

Size: Diameter : 0.27mm
Thickness : 0.13mm

Distribution: this species first occurs downhole at the top of the Coniacian (Zone F.I.8) of all the studied wells and is recorded rarely to abundantly in the sections.

Stensioeina granulata polonica Witwicka 1958

(Pl. 25, fig.2,a,b,c)

1958 Stensioina polonica Witwicka, pp.206-207, 265-267, pl.12, figs.21, 22, pl.13, fig.23.
1978 " granulata (Olbertz) var A. (Bailey (unpubl)); pp.211-212, pl.14, figs.13,14,15.
1979 " " polonica Witwicka; Bailey & Hart, p.161.
1981 " " " Witwicka; Hart et al., in Jenkins & Murray, p.220, pl.7.24, figs.7-9.

Description: test free, low trochospire, plano-convex; outline circular and periphery narrow and subacute to rounded; flat and involute on the umbilical side, evolute and convex on the spiral side; chambers distinct on both sides, nine in the final whorl, increasing gradually and uniformly in size as added; sutures distinct and slightly raised into septal ridges on the spiral side, flush and radial on the umbilical

side; aperture a narrow interiomarginal slit along the vertical edge of the final chamber, wall calcareous, surface perforate umbilically, and granular spirally.

Remarks: Trümper (1968) suggested this to be the intermediary form between the S. granulata (Olbertz) and S. exsculpta (Reuss) lineages.

The weakly developed ornament and subacute periphery serve to distinguish it from the subspecies S. granulata granulata (Olbertz).

Size: Diameter : 0.36mm
Thickness : 0.23mm

Distribution: 'topping' within the Late Santonian (Zone F.I.6) of wells 49/19-1 and 49/20-2, and within the Early Santonian (zone F.I.7) of well 44/2-1, this species is recorded rarely to moderately abundantly throughout the sections.

Stensioeina pommerana Brotzen 1936

(Pl.25, fig.3a,b,c)

1936 Stensioina pommerana Brotzen, p.166.
1941 " " Brotzen; Marie, p.218, pl.34, fig.317.
1951 " " Brotzen; Noth, p.71, pl.9, fig.12.
1953 " " Brotzen; Hagn, p.89, pl.8, fig.9.
1957 " " Brotzen; Hofker, pp.352-353, t.figs.407-408.
1957 " " var. juvenilis Hofker, pp.351-352, t.figs.405-406.
1957 " altissima Hofker, p.353-354, t.figs.409-410.
1961 " pommerana Brotzen; Vasilenko, p.67, pl.11, fig.6.
1962 " " Brotzen; Hiltermann & Koch, p.327, pl.51, figs.11-13.

1966 " " Brotzen; Hofker, p.30, pl.3, fig.65, pl.11, fig.126.

1966 " altissima Hofker; Hofker, p.42, pl.6, fig.53, pl.11, fig.125, pl.14, fig.86.

1966 " esnehensis Nakady; Hofker, p.122, pl.19, fig.47.

1968 " pommerana Brotzen; Trumper, p.14, pl.4-7, fig.12.

1972 " " Brotzen; Hanzlikova, p.135, pl.40, figs.6,7.

1977 " " Brotzen; Koch, p.51, pl.11, figs.1-4.

1977 " " Brotzen; Villain, pp.58-59, pl.11, figs.10-12.

1977 " " Brotzen; Sliter, pl.13, figs.6-7.

1981 " " Brotzen; Hart et al., in Jenkins & Murray, p.220, pl.7.24, figs.10-12.

Description: test free, plano-convex trochospire; outline circular and periphery acute; flattened and evolute spirally with two and a half to three whorls visible; involute, strongly convex and domed umbilically with a large chamber flap covering the umbilical region; chambers distinct, curved, uninflated becoming inflated, increasing gradually and uniformly in size as added; sutures distinct, raised into a slightly irregular reticulose network with the spiral suture on the spiral side, radial and depressed on the umbilical side; aperture a low interiomarginal arch bordered by a distinct lip; wall calcareous and perforate umbilically, surface between sutures granular.

Remarks: this species can be distinguished from other members of the genus by its domed outline and umbilical chamber flap.

Size: Diameter : 0.38mm

Thickness : 0.19mm

Distribution: this species first appears 'downhole' within the Late Maastrichtian (Zone F.I.1) of wells 44/2-1 and 49/20-2 and within the Early Maastrichtian (Zone F.I.2) of well 49/19-1. It is recorded rarely to commonly in the studied sections.

CHAPTER 7

BIOSTRATIGRAPHY

7.1. Introduction

A consideration of factors affecting faunal recovery from the samples utilised in this study is necessary before any biostratigraphical results can be discussed. Quantitative analysis is unreliable because both size and quality of the samples is variable and faunal recovery is likely to have been affected by differential destruction of the more fragile taxa during drilling, 'caving' of fossils, possible size sorting of fossils during the circulation of 'cuttings' to the surface and differential damage (especially to fragile planktonic taxa) during processing.

The affect of 'caving' (i.e. downhole contamination) is to blur the biostratigraphic details. Because of this first stratigraphic appearances of taxa can only be used with limited accuracy and assemblage details only give restricted information. This necessitates concentration on extinctions of taxa (i.e. the highest occurrences downhole, or 'tops'), and these are used almost exclusively in the biostratigraphic scheme proposed here.

7.2. Previous investigations

A considerable amount of literature concerning the stratigraphic details of the Upper Cretaceous succession in the British Isles has been published during the last twenty-five years, including the results of work by Barr (1962, 1966 a,b), Bailey (1975, 1978 (unpubl.)), Swiecicki (1980 (unpubl.)) Carter & Hart (1977), and Hart et al. (1981). Elsewhere in Europe, Upper Cretaceous foraminifera have been the subject

of many investigations including work in Belgium and Northern France (Robaszynski et al. 1980, 1982), France (Marie 1938, 1941), Germany (Koch 1977), Poland, (Gawor-Biedowa 1969, 1972, 1980, 1982) and Sweden (Brotzen 1936, 1942, 1945, 1948), many of the results of which are applicable to the North Sea Basin. Recently, many European micropaleontologists have collaborated to produce monographs of mid-Cretaceous planktonic foraminifera (Robaszynski & Caron 1979) and Upper Cretaceous planktonic foraminifera (Robaszysnki, Caron et al. 1984). Most biostratigraphic details concerning Upper Cretaceous strata of the North Sea Basin as yet remain unpublished with the exception of Burnhill & Ramsay (1981).

The zonation scheme presented here has evolved by comparison with these published records and utilises taxa which have a wide distribution, that are readily recognisable and occur in reasonable numbers.

7.3. Foraminiferid zonation

In the present study one zonal scheme is proposed for the Upper Cretaceous using both benthonic and planktonic taxa. The zones are 'interval zones' as used by Hedberg (1976); the top of each zone is defined by the highest occurrence of the zonal index species and the base is automatically defined by the top of the underlying zone. The sequence has been divided into 12 interval zones:-

Zone F.I.1 (unnamed)

This is the highest zone recognised in the scheme and potentially includes sediments to the base of the overlying Tertiary strata. The zone is characterised by a predominance of benthonic taxa including Bolivina incrassata, Bolivinoides draco and Osangularia navarroana.

Planktonic species are rare but include Heterohelix striata and Rugoglobigerina rugosa. The planktonic species recorded elsewhere as characterising the Late Maastrichtian, such as Racemigumbelina fructicosa and Pseudotextulariella elegans, have not been recorded in this study; the Late Maastrichtian age is designated on the basis of the benthonic species found in association.

Zone F.I.2 (Bolivinoides miliaris Zone)

The top of this zone is defined by the highest occurrence of the benthonic species Bolivinoides miliaris. This is usually found in association with rare B. decoratus and common or abundant Cibicidoides (?) gp. voltziana, together with the planktonics Archaeoglobigerina cretacea and Globotruncana arca. The fauna characterising this zone is indicative of an Early Maastrichtian age.

Zone F.I.3. (Globorotalites hiltermanni Zone)

The top of this zone is defined by the highest occurrence of the benthonic Globorotalites hiltermanni, which is elsewhere recorded as being restricted to the top of the Late Campanian in its range (e.g. Hart et al. 1981). This 'interval zone' is characterised by a diverse fauna dominated by benthonic taxa, including Gavelinella monterelensis, G. clementiana, Globorotalites micheliniana and Reussella szajnochae szajnochae. The top of this zone corresponds to the Maastrichtian-Campanian boundary.

Zones F.I.2 and F.I.3 in boreholes 49/20-2 and 49/19-1 are marked by a low diversity fauna of predominantly benthonic taxa of unusually large size (2-3 times the normal size), associated with rare planktonic taxa; this fauna has not been recorded from borehole 44/2-1. The main taxa involved include Arenobulimina elevata, A. courta, Ataxophragmium

rimosum, A. variable, A.sp.A. sp. nov., Cibicidoides (?) gp. voltziana, Eggerellina brevis, Orbignyna ovata and smooth Lenticulina sp. Further study may prove this fauna to be a useful local stratigraphic marker (see Ball, in press).

Zone F.I.4. (Stensioeina exsculpta gracilis Zone)

The top of this zone is defined by the highest occurrence of the subspecies Stensioeina exsculpta gracilis. The benthonics Gavelinella stelligera and G. thalmanni also 'top' within this zone. F.I.4. equates with a mid-Campanian age.

Zone F.I.5. (Gavelinella cristata Zone)

The highest occurrence of the benthonic species Gavelinella cristata is used to define the top of this zone and the top of the Early Campanian. Bolivinoides strigillatus and Reussella kelleri are characteristic of this zone.

Zone F.I.6 (Stensioeina exsculpta exsculpta Zone)

The highest occurrence of the subspecies Stensioeina exsculpta exsculpta is used to define the top of Zone F.I.6 in the present scheme; the top of this zone corresponds to the Campanian-Santonian boundary. The planktonic species Marginotruncana marginata and Whiteinella baltica also 'top' within this zone.

Zone F.I.7 (Marginotruncana pseudolinneiana Zone)

The passage into Early Santonian chalk, and the top of Zone F.I.7 is marked by the highest occurrence of the planktonic Marginotruncana pseudolinneiana, which occurs commonly throughout this interval. The

zone is characterised by a marked increase in the numbers of planktonic forms including common Marginotruncana marginata and Whiteinella baltica.

Zone F.I.8 (Stensioeina granulata granulata Zone)

The top of this zone is defined by the highest occurrence of the benthonic subspecies Stensioeina granulata granulata. This zone, as in the overlying one, is characterised by a dominance of planktonic taxa. The top of F.I.8 corresponds to the Santonian-Coniacian boundary.

Zone F.I.9 (Whiteinella aprica Zone)

The top of this zone is defined by the highest occurrence of the planktonic foraminiferid Whiteinella aprica. This species is known to range up into the Late Turonian of N.W.Europe (e.g. Robasyznski et al. 1979; Hart et al. 1981) and its presence therefore indicates penetration of chalk of definite Turonian age. The top occurrense of W. aprica is taken to mark the top of the Turonian in the present scheme.

F.I.10 (Dicarinella hagni Zone)

The top occurrence of the planktonic Dicarinella hagni is used to define the top of the Early Turonian, and Zone F.I.10. This zone is characterised by a moderately diverse assemblage dominated by planktonic taxa including Dicarinella algeriana and Praeglobotruncana stephani, both which 'top' within this zone. The benthonic species Lingulogavelinella globosa also has its highest occurrence within this zone, which, by comparison with published records confirms the Early Turonian age.

F.I.11 (unnamed)

The top of this zone is taken at the Plenus Marl - clearly indicated by the a distinct log character in both the Gamma Ray and Formation Density Logs; this equates with the Turonian-Cenomanian boundary. The benthonic foraminiferids Arenobulimina advena and Gavelinella baltica have their highest occurrence at, or near to, the top of this zone. Gavelinella cenomanica, G. intermedia, Plectina cenomana and Eggerellina mariae also 'top' within this zone. This assemblage is recorded elsewhere as indicating a Late-Middle Cenomanian age.

F.I.12 (Praeglobotruncana delrioensis Zone)

The top of the Middle-Early Cenomanian, and Zone F.I.12 is defined by the highest occurrence of the planktonic Praeglobotruncana delrioensis. This is the lowest zone recognised; the lower boundary for the zone is taken at the base of the Chalk Group as defined by the distinct decrease in the Gamma Ray Log signiture and the corresponding increase in the Formation Density Log signiture (where available).

The separation of P. delrioensis from P. stephani is often difficult as these two species belong to a single evolutionary plexus beginning with P. delrioensis (see remarks section for P. delrioensis in Chapter 6). However, it is known that P. delrioensis evolves into P. stephani during the Middle Cenomanian and that end members of this plexus are distinct (Carter & Hart 1977) and can be recognised. This part of the section in all of the studied well sections is characterised by abundant caving and a generally poor fauna. Because of the absence of any other age restricted taxa, the highest occurrence of definite forms assignable to the species P. delrioensis has been used to define the top of this zone.

7.4. Section details

The faunal range charts for the three wells studied, together with the biostratigraphic results are presented in Enclosures 1, 2 and 3.

Shell 44/2-1 (Enclosure 1)

The top of the Late Cretaceous is defined by the distinct decrease seen in the Gamma Ray Log signiture at 2,980'. The samples examined from the interval 2,980'-3,180' yielded a microfauna dominated by benthonic taxa, including common Ammodiscus cretaceus, Gavelinella bembix and Stensioeina pommerana (below 3,000'). Planktonic taxa were rarely recorded; Rugoglobigerina rugosa is present in number below 3,060'. The section between 2,980' and 3,180' corresponds to Zone F.I.1 and the Late Maastrichtian. The presence of Late Cretaceous taxa in the shallowest samples examined (2,910'-2,980') is thought to be a result of reworking.

The first occurrence of the benthonic species Bolivinoides miliaris below 3,180' indicates the penetration of the Early Maastrichtian Zone F.I.2; The age is confirmed by the first occurrence 'downhole' of Angulogavelinella bettenstaedti at this level. Other Early Maastrichtian species recorded from this interval include the planktonics Globotruncana arca (below 3,210') and Archaeoglobigerina cretacea (below 3,300') towards the base of the zone. The fauna is otherwise characterised by common to abundant Bolivina incrassata, Osangularia navarrona, Rugoglobigerina rugosa, R. rotundata, R. milamensis and Stensioeina pommerana.

The Maastrichtian-Campanian boundary is taken at 3,330' where the benthonic Globorotalites hiltermanni has its highest occurrence; this marks the top of the Zone F.I.3. The Late Campanian age is confirmed by

the presence of Gavelinella monterelensis (below 3,360') a species which is recorded elsewhere as being restricted to the top of the Campanian, (e.g. Hart et al. 1981), G. lornieana (below 3,540') and G.clementiana laevigata (below 3,720'). The fauna of this zone is diverse with Bolivina incrassata, Stensioeina pommerana, Osangularia cordieriana and Archaeoglobigerina cretacea occurring commonly.

The highest occurrence of the subspecies Stensioeina exsculpta gracilis at 3,960' marks the top of Zone F.I.4 and the mid-Campanian. Gavelinella thalmanni and G. stelligera top within this interval (at 3,990') confirming the designated age. This zone appears to be only thinly represented in this well.

The top of the Early Campanian and Zone F.I.5 is taken at 4,050' where the benthonic Gavelinella cristata is recorded for the first time downhole. The appearance of Bolivinoides strigillatus at 4,240' and Reussella Kelleri at 4,280' supports an Early Campanian age for this part of the section.

The highest record of the subspecies Stensioeina exsculpta exsculpta at 4,400' indicates penetration of definite Santonian chalk. This equates with Zone F.I.6. Both faunal diversity and quality of preservation decreases throughout this interval.

The appearance downhole of the planktonic Marginotruncana pseudolinneiana at 4,460' marks the presence of Early Santonian chalk and Zone F.I.7. The section below this level is characterised by a marked increase in the abundance of planktonic taxa, including common to abundant M. pseudolinneiana, M. marginata and Dicarinella canaliculata.

The Santonian/Coniacian boundary is defined by the appearance of Stensioeina granulata granulata at 4,520'. This corresponds to Zone F.I.8 in the present scheme. The fauna continues to be dominated by planktonic taxa including many of the species recorded from the overlying interval.

Sample quality below c.4,600' is poor because of contamination by caving, and precludes a satisfactory biostratigraphical breakdown. The highest occurrence of the planktonic species Whiteinella aprica at 4,610' indicates penetration of definite Turonian strata and the top of Zone F.I.9. As noted previously this species is known to range up into the Late Turonian in N.W. Europe (e.g. Robaszynski et al. 1979; Hart et al. 1981), and is used to define the top of the Turonian stage in the present scheme. A Turonian age is confirmed by the occurrence of Gavelinella tourainensis (below 4,610').

Early Turonian chalk is penetrated at 4,730', indicated by the top occurrence of the planktonic Dicarinella hagni at this level. The designated age is confirmed by the presence of the planktonics D. algeriana, Praeglobotruncana helvetica together with the benthonic Lingulogavelinella globosa below 4,790'. This assemblage equates with Zone F.I.10.

The Plenus Marl is indicated by a sudden increase in the Gamma Ray log signiture at 4,910', and marks the Turonian/Cenomanian boundary. Below this depth, Cenomanian taxa recorded include Eggerellina mariae, Gavelinella baltica, G. cenomanica and Gr. gp. intermedia. This assocation corresponds to Zone F.I.11 of Late-Middle Cenomanian age.

The highest occurrence of the planktonic Praeglobotruncana delrioensis at 4,940' indicates penetration of Middle-Early Cenomanian strata and Zone F.I.12. The fauna is dominated by an abundance of caved forms from overlying strata.

Shell 49/19-1 (Enclosure 2)

The top of the Late Cretaceous is defined by the distinct decrease in the Gamma Ray Log signiture at 1,460'. The samples examined from the interval (1,460'-1,530') yielded a sparse microfauna of predominantly benthonic taxa including Praebulimina laevis (below 1,470') and Ataxophragmium variabile (below 1,500'). The fauna indicates a Late Maastrichtian age and corresponds to Zone F.I.1. The presence of Late Cretaceous taxa in the shallowest samples examined (1,350'-1,460') is thought to be a result of reworking.

The top of Zone F.I.2 and the Early Maastrichtian is defined by the highest occurrence of the benthonic Bolivinoides miliaris at 1,530'. This zone is apparently only represented by 30' in this well. The designated age is confirmed by the occurrence of Eponides beisseli below 1,530'.

The Maastrichtian/Campanian boundary is defined by the first occurrence of the benthonic Globorotalites hiltermanni at 1,560'. The Late Campanian age is confirmed by the presence of Archaeoglobigerina cretacea, Globotruncana arca (below 1,590'), Gavelinella monterelensis (below 1,650') and G. clementiana laevigata (below 1,710'). This assemblage corresponds to Zone F.I.3.

The assemblages of Zones F.I.2 and F.I.3 are very distinct in that they are characterised by a low diversity fauna of unusually large (individuals of two to three times the normal size) agglutinated and

calcareous benthonic foraminifera, associated with rare planktonic taxa. This distinct assemblage appears to provide a useful local stratigraphical marker (see Ball, in press).

The appearance of the subspecies Stensioeina exsculpta gracilis at 1,880' indicates chalk of definite mid Campanian age (Zone F.I.4). Species that confirm this age and that top within this interval include Bolivinoides culverensis (below 1,880'), Reussella szajnochae praecursor and Gavelinella thalmanni (below 1,910'). The fauna throughout this interval is characterised by common to abundant Stensioeina pommerana, S. exsculpta gracilis, Globorotalites micheliniana and the planktonics Archaeoglobigerina cretacea and Globotruncana bulloides.

The highest occurrence of the benthonic Gavelinella cristata at 2,000' indicates penetration of Early Campanian chalk and Zone F.I.5. This species is associated at this level with Reussella kelleri confirming the Early Campanian age. The fauna is otherwise very similar to that recorded in the overlying zone, being characterised by common to abundant Stensioeina pommerana, S. exsculpta gracilis, Globorotalites micheliniana, Archaeoglobigerina cretacea and Globotruncana bulloides.

The Campanian/Santonian boundary is defined by the highest occurrence of the subspecies Stensioeina exsculpta exsculpta at 2,060'; this corresponds to the top of Zone F.I.6. Taxa to top within this interval include Whiteinella baltica (at 2,150'), Marginotruncana marginata and Stenisioeina granulata polonica (both at 2,180'), confirming a Late Santonian age. The microfauna is otherwise characterised by common Globotruncana linneiana, Stensioeina exsculpta exsculpta and Osangularia cordieriana, together with abundant S. exsculpta gracilis and G. bulloides.

The appearance downhole of the planktonics Marginotruncana pseudolinneiana and Dicarinella canaliculata at 2,210' indicate penetration of Early Santonian chalk and Zone F.I.7. This interval is characterised by a marked increase in planktonic forms with M. marginata, M. pseudolinneiana and Globotruncana bulloides being commonly recorded. The benthonics Stensioeina exsculpta exsculpta, S. granulata polonica and Osangularia whitei are also common.

The Santonian/Coniacian boundary is taken at 2,330' where Stensioeina granulata granulata has its highest record. This corresponds to the top of Zone F.I.8. The microfauna otherwise resembles that recorded in the overlying zone, with planktonic forms occurring commonly.

The top of the Turonian and Zone F.I.9 is defined by the highest occurrence of the planktonic Whiteinella aprica at 2,520'. The designated age is confirmed by the presence of Hedbergella delrioensis below 2,520'. The fauna continues to be dominated by planktonic taxa including common Marginotruncana marginata, M. pseudolinneiana and Dicarinella canaliculata.

Early Turonian chalk is encountered at 2,630' as indicated by the record of Dicarinella hagni associated with D. algeriana, Praeglobotruncana helvetica and Gavelinella tourainensis at this depth. Other species confirming the Early Turonian age to top within this interval are Praeglobotruncana stephani (below 2,650') Lingulogavelinella globosa (below 2,770') and Hedbergella planispira (below 2,840'). Microfaunas recovered from this interval and below are badly preserved, and sample quality is poor due to heavy caving.

The distinct electric log signiture of the Plenus Marl is seen at 2,865', indicating the Turonian/Cenomanian boundary at this depth. A Late-Middle Cenomanian age is confirmed by the presence of Arenobulimina advena (below 2,870'), Plectina cenomana, Gavelinella gp. intermedia (both below 2,890'), G. baltica and G. cenomanica (below 2,900'). This interval is assigned to Zone F.I.11.

The common occurrence of the planktonic Praeglobotruncana delrioensis below 2,910' indicates a Middle-Early Cenomanian age (Zone F.I.12).

Shell 49/20-2 (Enclosure 3)

The top of the Late Cretaceous is defined by the distinct decrease in the Gamma Ray Log signiture and a corresponding marked increase in the Formation Density Log signiture seen at 2,780'. The samples examined from the interval 2,780'-3,170' yielded a rich, and diverse microfauna dominated by benthonic species. These include Bolivina incrassata (below 2,840') and Stensioeina pommerana (below 2,900'), associated with common Lenticulina spp. and Orbignyna ovata. This assemblage corresponds to Zone F.I.1 of the Late Maastrichtian. The presence of Late Cretaceous taxa in the shallowest samples examined (2,720'-2,780') is thought to be the result of reworking.

The top of the Early Maastrichtian is defined at 3,170' at the highest occurrence of the benthonic Bolivinoides miliaris. B. decoratus is recorded below 3,320'; this species can range up into the Early Mastrichtian although it is more common in the Late Campanian. Its presence here in the absence of age diagnostic Late Campanian forms, is used to confirm an Early Maastrichtian age (Zone F.I.2). The fauna is otherwise characterised by common Lenticulina spp., Cibicidoides (?) gp. voltziana, Orbignyna ovata and Gyroidinoides nitida.

The highest occurrence of Globorotalites hiltermanni and Gavelinella monterelensis at 3,470' defines the Campanian/Maastrichtian boundary. Other species to top within this interval include Gavelinella clementiana laevigata, (at 3,920') Globotruncana arca (at 4,370') and Reussella szajnochae szajnochae (at 4,440'), confirming the designated age. The microfauna is both rich and diverse throughout this long interval and below c.4,550' is characterised by the common occurrence of Cibicidoides (?) gp. voltziana, Osangularia cordieriana, Arenobulimina obliqua, A. courta, Stensioeina pommerana and Globorotalites micheliniana, and is assigned to Zone F.1.3.

The faunas of Zones F.I.2 (below c.2,870') and F.I.3 are of a low diversity, but include forms of two to three times the normal size; this distinct assemblage appears to provide a useful local stratigraphical marker (see above, and Ball in press).

Mid Campanian chalk (and Zone F.I.4), is penetrated at 5,130', as indicated by the record of the subspecies Stensioeina exsculpta gracilis at that depth. Gavelinella stelligera is present in the faunal assemblage below 5,420'; this species can range up into the Late Campanian although it is more common in the mid Campanian. Its presence here in association with S. exsculpta gracilis is used to confirm the designated age. The fauna is otherwise rich and diverse and Globorotalites micheliniana, Gavelinella clementiana clementiana, S. exsculpta gracilis, S. pommerana, Osangularia cordieriana and Arenobulimina obliqua are amongst those commonly recorded.

The presence of Gavelinella cristata below 5,480' associated with Bolivinoides strigillatus below 5,630' indicates a definite Early Campanian age for this part of the section. The microfauna otherwise continues to be rich and diverse with an abundance of Globorotalites

micheliniana, Gavelinella usakensis, Osangularia whitei and the planktonic Globotruncana bulloides. This corresponds to Zone F.I.5 of the present scheme.

The Campanian/Santonian boundary is placed at 5,660' where Stensioeina exsculpta exsculpta and Whiteinella baltica are recorded for the first time 'downhole'. A Late Santonian age for this interval is confirmed by the presence of Marginotruncana marginata (below 5,690') and Stensioeina granulata polonica (below 5,720'). The recorded assemblage corresponds to Zone F.I.6.

The highest occurrence of the planktonic Marginotruncana pseudolinneiana at 5,750' indicates penetration of Early Santonian age and Zone F.I.7. Below this depth, there is an overall increase in the planktonic element of the fauna, and Globotruncana bulloides, Marginotruncana pseudolinneiana and M. marginata are recorded in abundance. The presence of M. marginata in number is characteristic of the Early Santonian, thus confirming the designated age.

The Santonian/Coniacian boundary is marked by the incoming 'downhole' of the subspecies Stensioeina granulata granulata at 5,810'. The faunal assemblage is similar to that recorded from the overlying interval, with planktonic forms dominating. These include Globotruncana bulloides, Whiteinella baltica, Marginotruncana pseudolinneiana, M. marginata, Dicarinella canaliculata and Hedbergella brittonensis (=Whiteinella brittonensis of Robaszynski & Caron 1979) in number (Zone F.I.8).

Below this level, sample quality is affected by heavy caving from the overlying intervals and the preservation of the microfauna is poor.

The highest occurrence (at 6,020') of the planktonic species Whiteinella aprica defines a level within the Late Turonian and is here used to define the Coniacian/Turonian boundary, and the top of Zone F.I.9. The faunal assemblage resembles that recorded from the overlying interval and includes many 'caved' forms - Lingulogavelinella sp. cf. L. vombensis is recorded for the first time at 6,080': this is a species usually characteristic of the Early Santonian-Late Coniacian. Its presence here associated with Turonian forms is thought to be a result of 'caving'.

The first record of the planktonic Dicarinella hagni at 6,170' marks the top of the Early Turonian and Zone F.I.10. This age is confirmed by the presence of Gavelinella tourainensis (also at 6,170'), Lingulogavelinella globosa (below 6,260') and Dicarinella concavata (below 6,410').

The marked increase in the Gamma Log signiture and the decrease in the Formation Density Log marking the Plenus Marl, occurs at 6,505'; this indicates the Turonian/Cenomanian boundary. A Late-Middle Cenomanian age is confirmed by the occurrence of Arenobulimina advena, Plectina cenomana, Gavelinella baltica and Hedbergella planispira below 6,520'. This assemblage is assigned to Zone F.I.11.

The Middle-Early Cenomanian is penetrated at 6,560' as indicated by the highest occurrence of the planktonic Praeglobotruncana delrioensis at this level. This species is recorded commonly below 6,590' and is associated with common Gavelinella gp. intermedia and G. cenomanica. This interval corresponds to Zone F.I.12 of the present scheme.

CHAPTER 8

STRATIGRAPHICAL CONCLUSIONS AND CORRELATION OF THE WELL SECTIONS

8.1 Introduction

The lithostratigraphic succession (as discussed in Chapter 5), together with the biostratigraphic conclusions (as presented in Chapter 7) of the Late Cretaceous sequence of the three well sections studied is summarised in Figures 8.1, 8.2 and 8.3, and the variation in thickness of each zone is summarised in Figure 8.4. The highest occurrence of key species have been used to define apparent regionally consistent "palaeoevents". The 12 major palaeoevents that were defined in Chapter 6 have been recognised in the studied sections and have been used as datum planes for correlation between the sections. The stratigraphy defined in the present study results from the age interpretation of these palaeoevents.

8.2 Correlation of the well sections

A single north-south section across the area was considered in an attempt to correlate the three well sections studied. Because of the ease in which the 'Plenus Marl' could be picked from the electric logs for all three wells, it was used as a datum for the section (see Enclosure 4).

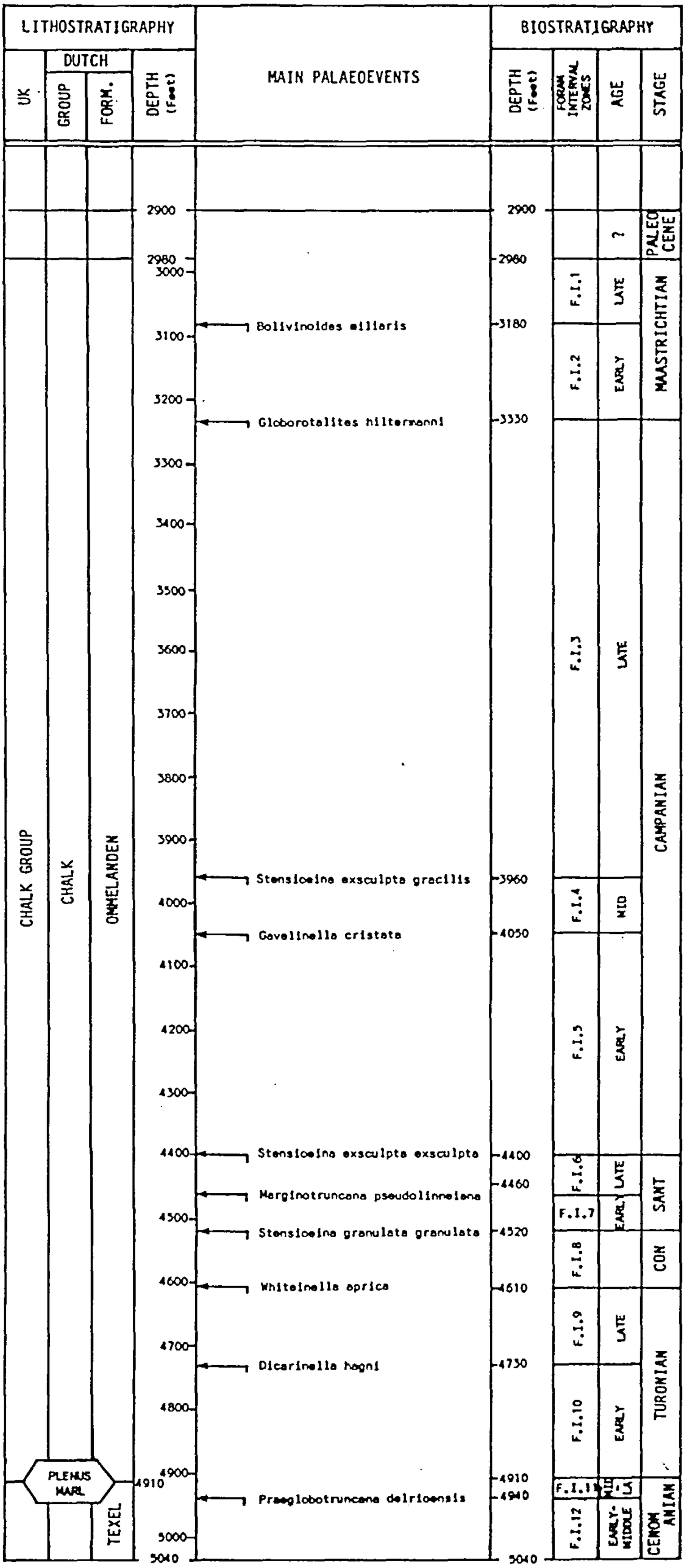

Fig. 8.1 Stratigraphic summary of well 44/2-1

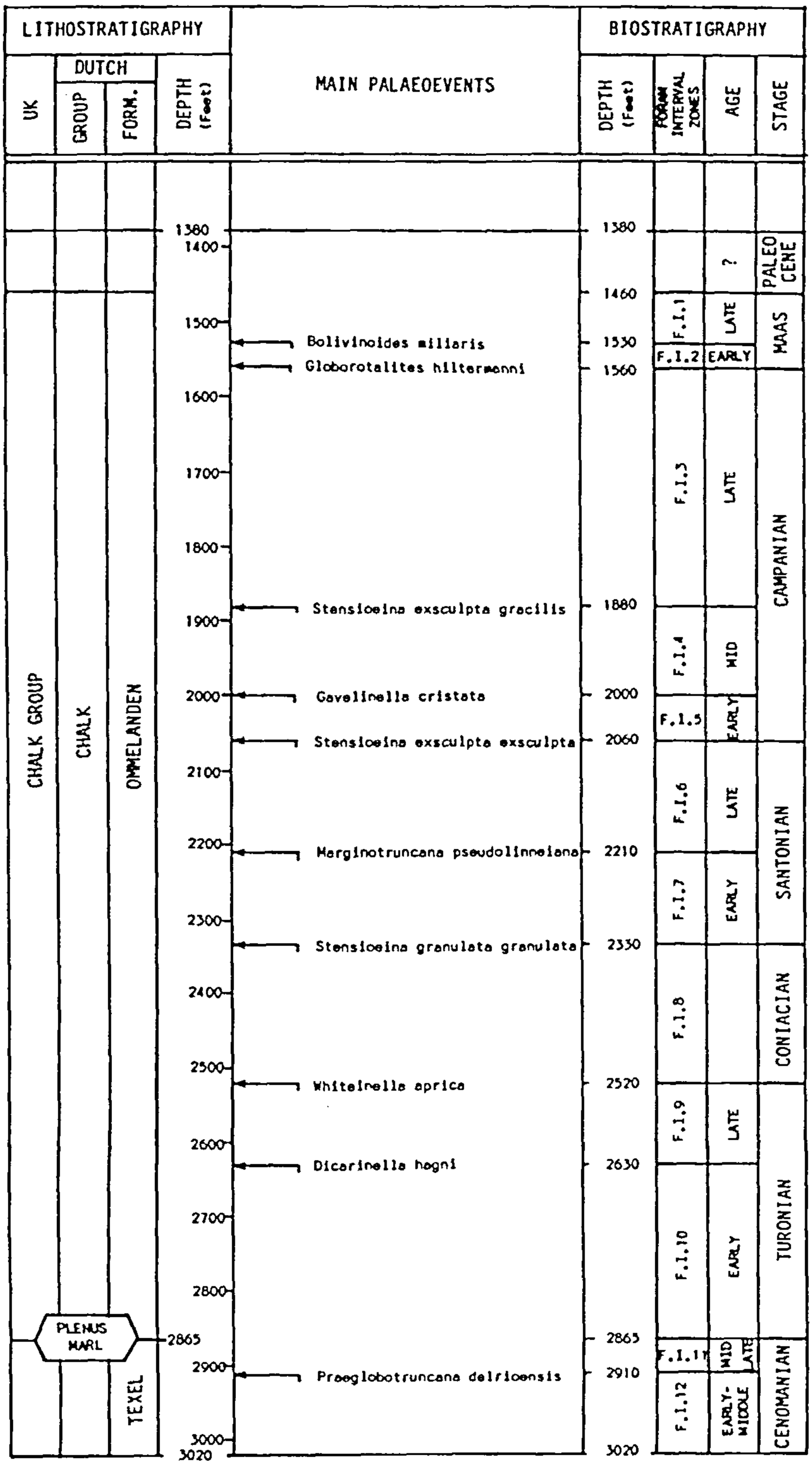

Fig. 8.2 Stratigraphic summary of well 49/19-1

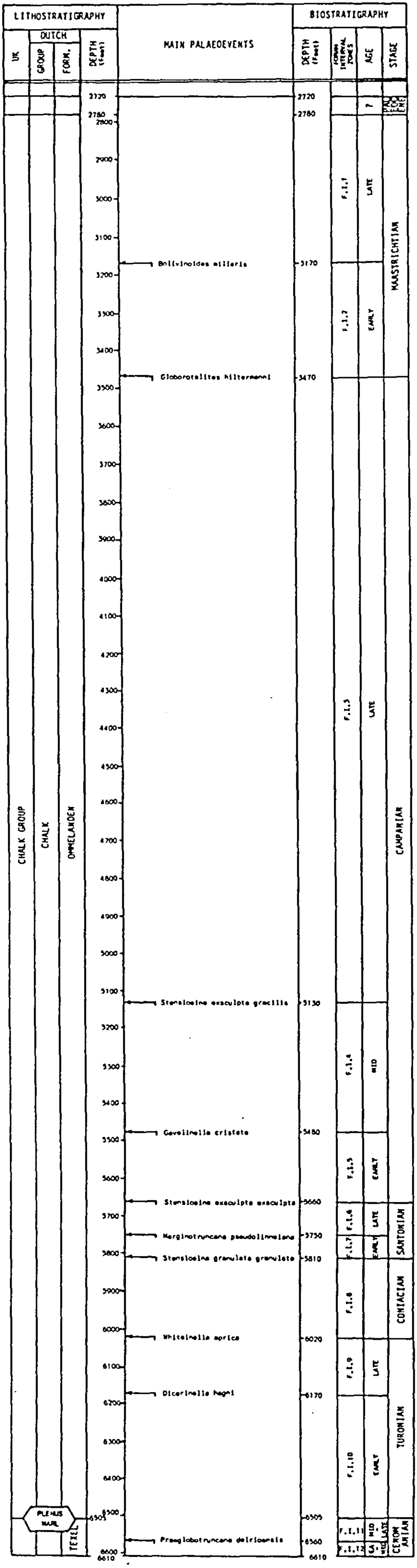

Fig. 8.3 Stratigraphic summary of well 49/20-2

STAGE	AGE	ZONE	WELLS		
			44/2-1	49/20-2	49/19-1
MAAS	LATE	F.I.1	200'	390'	130'
	EARLY	F.I.2	150'	300'	30'
CAMPANIAN	LATE	F.I.3	630'	1,660'	320'
	MID	F.I.4	90'	350'	120'
	EARLY	F.I.5	350'	180'	60'
SANTONIAN	LATE	F.I.6	40'	90'	150'
	EARLY	F.I.7	80'	120'	60'
CON		F.I.8	90'	210'	190'
TURONIAN	LATE	F.I.9	120'	150'	110'
	EARLY	F.I.10	180'	335'	235'
CENOMANIAN	LATE -MID	F.I.11	30'	55'	45'
	MID- EARLY	F.I.12	100'	50'	110'

Fig. 8.4 Thicknesses of zones in the studied wells
(Thicknesses in feet)

Late Maastrictian

Thickness : 44/2-1 200'
49/20-2 390'
49/19-1 130'

A considerable variation in thickness for this interval is seen across the section attaining a maximum thickness in well section 49/20-2 (390'). It is represented by a thinner interval to both the north and the south of this well, the minimum development being seen in well 49/19-1 to the south (130').

Early Maastrichtian

Thickness : 44/2-1 150'
49/20-2 300'
49/19-1 30'

This interval varies considerably in thickness across the section. The Early Maastrichtian has its greatest thickness in well section 49/20-2 where it is twice the thickness of the same interval in well 44/2-1, approximately 95 miles to the north. To the south, this interval is considerably condensed by comparison, being represented by just 30' in well section 49/19-1.

Late Campanian

Thickness : 44/2-1 630'
49/20-2 1,660'
49/19-1 320'

This interval forms the greatest part proportionally in all the studied well sections, and again shows considerable variation from north to south across the section. It attains a maximum thickness of 1,660' in well 49/20-2. It is represented by a thinner interval to both the north and south of this well, the minimum development being seen in well 49/19-1 to the south (320').

Mid-Campanian

Thickness : 44/2-1 90'
49/20-2 350'
49/19-1 120'

This interval attains a maximum thickness in well section 49/20-2. The minimum representation of this interval is seen to the north, where only 90' of section is assigned to this interval. In well section 49/19-1 to the south, this interval is represented by 120' which again by comparison with that seen in well 49/20-2 is also a thinner interval.

Early Campanian

Thickness : 44/2-1 350'
49/20-2 180'
49/19-1 60'

This interval attains a maximum thickness of 350' to the north of the area in well section 44/2-1, and a minimum of 60' to the south in well section 49/19-1.

Late Santonian

Thickness : 44/2-1 40'
49/20-2 90'
49/19-1 150'

The reverse trend to the overlying part of the section is seen in the representation across the section for this interval. The Late Santonian interval attains a maximum thickness to the south of the area, being represented by 150' in well section 49/19-1, and a minimum of 40' in well section 44/2-1 to the north.

Early Santonian

Thickness : 44/2-1 80'
49/20-2 120'
49/19-1 60'

A considerable variation in the thickness of this interval is seen across the section. A maximum development is seen in well section 49/20-2 where 120' is recorded. To the north, a thinner interval is

recorded - in well section 44/2-1 the Early Santonian is represented by 80'. The minimum thickness for this interval is seen to the south where only 60' is recorded from well section 49/19-1.

Coniacian

Thickness : 44/2-1 90'
49/20-2 210'
49/19-1 190'

The minimum thickness for this interval is recorded to the north where in well section 44/2-1 it is represented by 90'. This interval is considerably thicker to the south by comparison, where 190' of Coniacian is recorded from well section 49/19-1. Maximum thickness is recorded in well section 49/20-2, where the interval comprises 210' of section.

Late Turonian

Thickness : 44/2-1 120'
49/20-2 150'
49/19-1 110'

A maximum of 150' for this interval is recorded from well section 49/20-2. It is represented by a thinner interval to the north; 120' of Late Turonian chalk is recorded from well section 44/2-1, and a minimum thickness is recorded to the south - in well section 49/19-1, this interval is represented by 110'. However, the overall variation in the thickness of this interval along the N-S section is not considerable.

Early Turonian

Thickness : 44/2-1 180'
49/20-2 335'
49/19-1 235'

Considerable variation in the thickness of this interval is seen across the section. The minimum thickness is seen to the north in well section 44/2-1 where it is represented by 180'. It is considerably thicker to the south by comparison, where 235' of Early Turonian strata are recorded from well section 49/19-1. This interval attains a maximum thickness of 335' in well section 49/20-2.

Late-Middle Cenomanian

Thickness : 44/2-1 30'
49/20-2 55'
49/19-1 45'

The Late-Middle Cenomanian interval is proportionally a thin interval in all of the studied well sections. It attains a maximum thickness of 55' in well section 49/20-2. It is represented by a thinner interval in well section 49/19-1 where 45' of Late-Middle Cenomanian chalk is recorded. This interval attains a minimum thickness to the north of the area, where in well 44/2-1 it is represented by 30' of section.

Middle-Early Cenomanian

Thickness : 44/2-1 100'
49/20-2 50'
49/19-1 110'

A maximum of 110' for this interval is recorded from well section 49/19-1 to the south. It is represented by a marginally thinner interval to the north where the Middle-Early Cenomanian chalk is represented by 100' in well 44/2-1. A minimum thickness of 50' is recorded from well 49/20-2.

8.3 Discussion and conclusions

A full Late Cretaceous sequence appears to be present in all of the three studied well sections, but noticeable differences in the thicknesses of the defined intervals occur.

These variations in thickness between the sections are difficult to interpret on a regional scale due to the absence of a well defined reference section. The lack of published or released data for the North Sea Basin is a limitation on the information available for comparative studies. The applicability of the data available is further limited for several reasons: wells are usually drilled where structures have been identified that are potentially capable of trapping oil or gas and are therefore generally sited over structural "highs" where successions are incomplete and therefore atypical. However, as more wells are drilled and more data is released, the availability of information is increasing.

Additionally, the objectives of most North Sea wells are in pre-Cretaceous strata and, as such, the Cretaceous is often regarded as 'overburden'. This has resulted in few details (particularly in old wells) of the Cretaceous being recorded, most of which have been taken from wire line logs-mainly Gamma Ray and Sonic. Any details available for the Cretaceous are further complicated by companies using different standards for dating, particularly in the "early days", so that thicknesses of Cretaceous sequences in wells of different fields may in fact be more similar than the published records suggest.

The effect of halokinetics and inversion tectonics may provide further difficulties in the interpretation of the differences seen in the thicknesses of the chalk sequences in the studied wells. In the North Sea area, it is known that the Late Cretaceous period was characterised by fully marine conditions with regional subsidence occurring, centred over an axial graben system (e.g. Hancock & Scholle 1975; Hancock 1984).

Tectonically, the Cretaceous seting was generally a continuation of that established during the Jurassic; ancient massifs were stable and were submerged by the Cretaceous sea and subsidence continued in the fault controlled basins. Additionally, broad downwarping occurred within some of the basins.

However, not all of the structural changes during the Cretaceous are related simply to broad downwarping and extensional faulting. Within the basins certain areas accumulated a thick sequence of Jurassic sediments; during the Cretaceous and Tertiary these areas experienced a reversal in this process so that they became areas of uplift along inversion axes. This change from basin to inversion axis was usually episodic and there is no general pattern of timing (Hancock

1984). In some cases, uplift along the inversion axes was sufficent to produce land (eg. east of Lowestoft there is a sandstone, possibly Turonian, within the Chalk).

In the U.K. southern North Sea Basin there are two inversion axes where Upper Cretaceous sediments are now absent. Each of these inversions involved two main phases of uplift and each phase would have caused thinning of the stages close to the inversion region. The two inversion axes are the Sole Pit Inversion and the Central Netherlands Inversion. Most of the effects of the Sole Pit Inversion are reported to disappear very rapidly, and within a short distance (eg. 3 miles), from the region of total Upper Cretaceous removal so that no obvious breaks in the succession can be seen (Hancock & Scholle 1975). The first phase of uplift along this axis occurred during Turonian to Santonian times and was much stronger than the second phase, which occurred during the Maastrichtian. The first definite phase of uplift of the Central Netherlands Inversion is recorded as occurring in the Santonian, but some of the evidence for this was destroyed by the erosion that resulted from the second and stronger phase of uplift that occurred during the Maastrichtian and Lower Paleocene.

Shell 49/19-1 and Shell 49/20-2

The sequences studied in well sections 49/19-1 and 49/20-2 are of particular interest as these two wells are only appproximately 12 miles apart but show marked differences in thickness. This may simply reflect differential subsidence between the two wells, but it is worth noting that the two wells are located in a sub-basin lying between the Sole Pit Inversion and the Central Netherlands Inversion and may have been affected by the phases of uplift experienced along these axes. No palaeontological evidence has been found to substantiate the presence

of any break in either well sequence which suggests that either inversion tectonics did not affect the sequences or alternatively the only affects observed were relative thinning.

Alternatively, there may exist breaks in the sequences that have not been identified. This may be a function of sample interval (i.e. 30' samples), and the limitations of ditch cuttings on the palaeontological data (i.e. 'caving' and the use of 'tops' only), all of which ultimately affect the quality of the proposed zonation scheme; breaks in the sequence may not be apparent because the resolution of the biozonation isn't fine enough.

With an awareness of the possible limitations of the proposed biozonation scheme, it has been attempted to relate the differences in thicknesses observed in wells 49/19-1 and 49/20-2 to inversion tectonics, assuming that during inversion, thinning on the margins of the subbasin occurred. Further biostratigraphic data is required to provide evidence that inversion did result in the thinning of the sequences (i.e. by the accurate identification and timing of breaks in the sequence) and that the differences in the sections are not due to differential subsidence of the subbasin.

The Cenomanian interval in the two wells under discussion is roughly comparable in thickness. However, there is a marked difference in the thicknesses of the Turonian intervals, being much thicker in well 49/20-2; this could simply be due to greater subsidence in the 49/20-2 area. However, the Sole Pit Inversion axis is close to the site of well 49/19-1, and it is known that the first phase of uplift along this axis started in the Turonian (Hancock & Scholle 1975). If these movements affected the 49/19-1 area, the result would be a

thinning of the sequence of the Turonian to Santonian interval in this well and would account for the differences seen for this part of the sequence.

The Coniacian to Early Santonian interval is represented by a slightly thicker section in well 49/20-2, but the differences in the zonal thicknesses between the two wells are not that great. However, during the Late Santonian interval, the reverse situation is seen and the section representing this part of the sequence is much thicker in well 49/19-1. Again, this could be related to greater subsidence in the 49/19-1 area. However, the Central Netherlands Inversion axis is close to the site of well 49/20-2, and it is known that inversion was taking place along this axis during the Santonian (Hancock & Scholle 1975). If these movements affected the 49/20-2 area, the result would be a thinning of the Santonian sequence in that well.

The most marked difference in thickness between the two wells is seen for the Campanian to Maastrichtian interval; the sequence is considerably thicker in well 49/20-2. This may be a result of very marked subsidence in the 49/20-2 area, but alternatively may be reflecting the second and stronger phase of uplift of the Central Netherlands Inversion during the Maastrichtian (Hancock & Scholle 1975), resulting in a thinning of the sequence in well 49/19-1.

Shell 44/2-1

A full Cretaceous sequence has also been recognised in well 44/2-1. However, because of the distance between this well and 49/19-1 and 49/20-2 (approximately 95 miles), the differences in zonal thicknesses between them have not been discussed. This well is known to be situated on the Mid-North Sea High, which was passive during Cretaceous times. Most of the Mid-North Sea High was submerged during the Albian

and submergence was completed in the Campanian when sea-level reached a maximum. The gradual submergence of the Mid-North Sea High would be expected to produce an onlapping sequence related to the rise in sea level. The recognition of a full sequence in well 44/2-1 suggests this well is situated on a part of the Mid North Sea High that was submerged early on (i.e. in the Albian). By examining other wells on this part of the high, a thinning of the sequence would be expected to occur landward.

By the recognition of "palaeoevents" as defined in the proposed biozonation scheme in Chapter 7, correlation of the three studied sections has proved possible. The dating and correlation of the sequences has shown significant differences in thicknesses to exist between the well sections, and these have been tentatively explained by position relative to 'palaeo-highs', differential subsidence and, or uplift along inversion axes in the area. By refining the biozonation scheme and examining more palaeontological evidence, it may be possible to prove the exact timing and extent of effect of these inversion events, which would ultimately help in a better understanding of basin evolution in the Southern North Sea area during Late Cretaceous times.

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APPENDIX I

LATEST CAMPANIAN - MAASTRICHTIAN FORAMINIFERA FROM THE DSDP LEG 80

1. Introduction and geological setting

Leg 80 of the Deep Sea Drilling Project, International Phase of Ocean Drilling, involved an area 250 km southwest of Ireland in the northern part of the Bay of Biscay (Fig.I.1) and was carried out during May - July 1981. This region has a complex geological structure due to its involvement in the rifting and drifting of Europe, Iberia and North America during the early Mesozoic and in the previous convergence between Europe, Iberia and Africa (Fig.I.2). The aim of Leg 80 was to provide information so that the structural evolution and palaeoenvironmental history of the region could be documented. It was sited in one of the few areas of the North Atlantic basin where open-hole drilling could reach strata deposited during the early stages of the evolution of a passive continental margin.

A transect of four cored boreholes was drilled across the broad, smooth, sediment-starved Goban Spur which forms part of the deep continental margin off France and the United Kingdon. The Spur lies between the Celtic Shelf and the Porcupine abyssal plain about 550 km west of Brest and Lands End (Fig.I.1), and slopes gently westward to depths of 1500 m and then abruptly steepens to depths of 4000-4500 m. Late Mesozoic and Tertiary pelagic sediments provide only a thin cover to the faulted granitic basement (Pautot et al. 1976). The throw of the faults is consistently towards the basin resulting in the top surface of each fault block tilting towards the continent (Roberts et al. 1980).

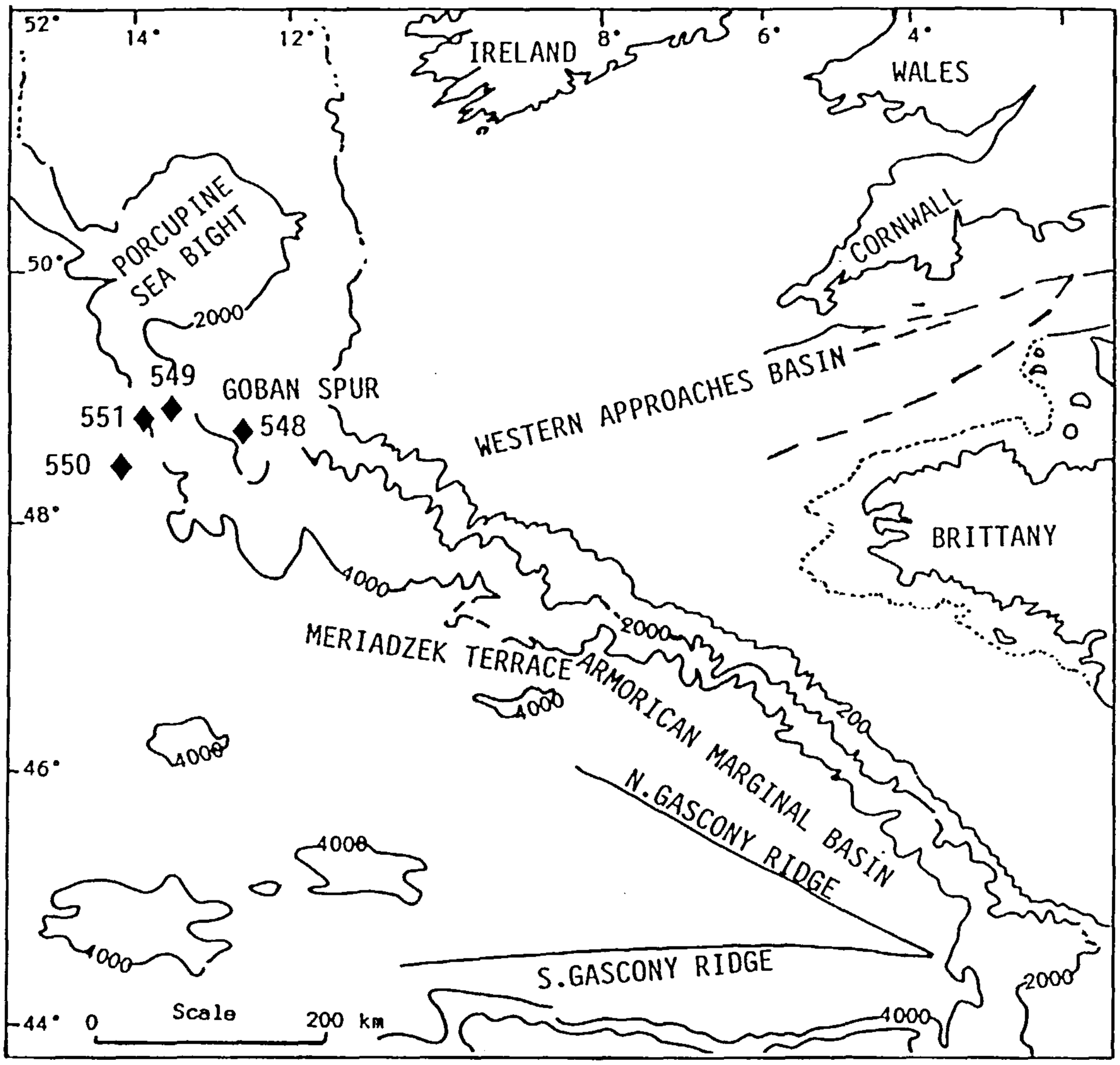
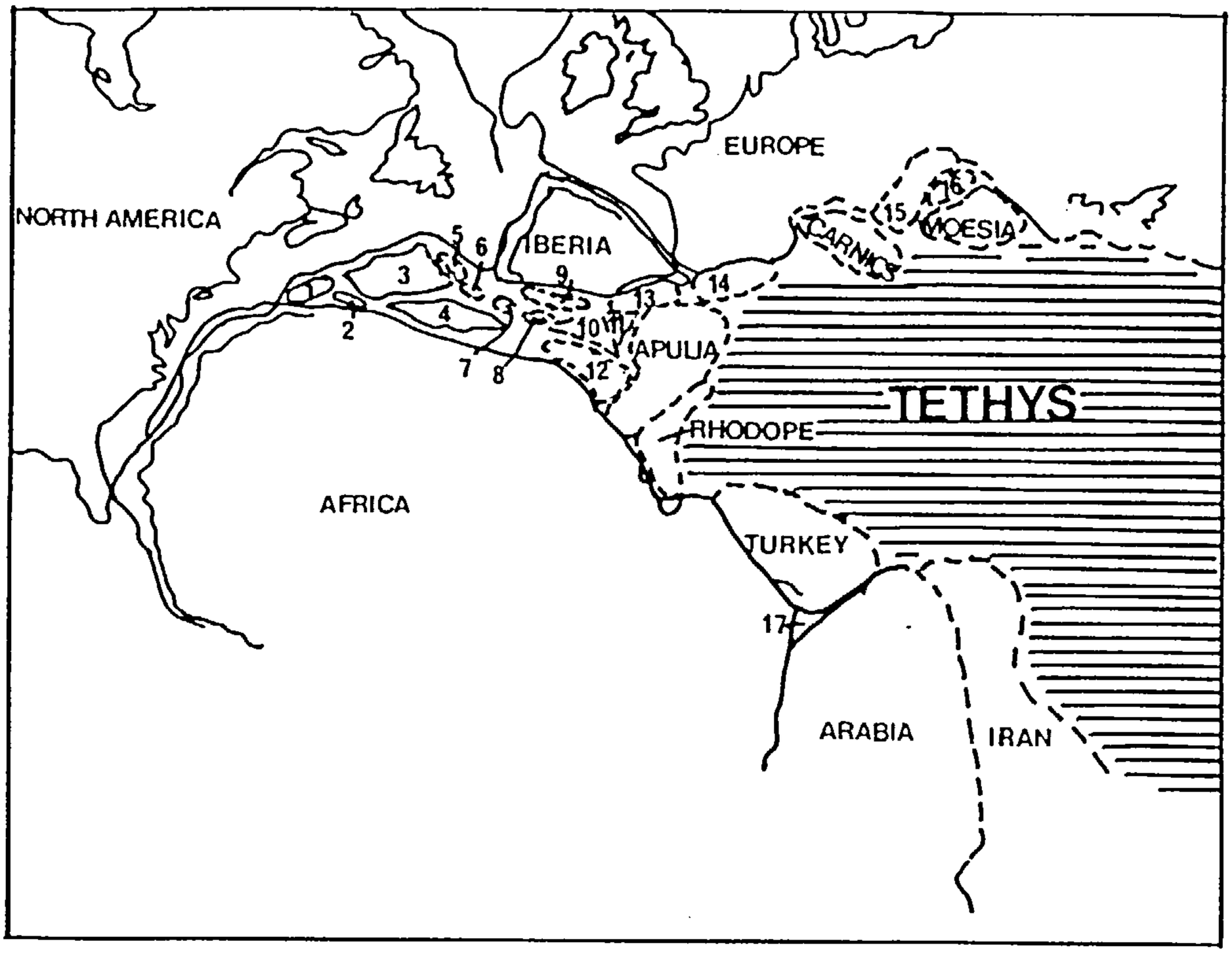


Fig. I.1 General physiography of the continental margins of the NE Atlantic with the location of DSDP sites (From Montadert et al)

Bathymetry in m. (from Berthois)

Fig. I.2 Proposed restoration of the North American, European and African Continents, the Iberian Block and numerous smaller blocks prior to Late Triassic times



(after Dewey et al. 1973).

1. Lanzorote (Fuerteventura)
2. Haha Block
3. Morroccan Meseta
5. Rif Block
6. Grand Kabylie Block
7. Petit Kabylie Block
8. Calabrian Block
9. Betic Block
10. & 11. Iblean Block
12. Chott Sahel
13. Balearic Block
14. Corsica-Sardinia Block
15. Tatra Block
16. Tirgu Mures Block
17. Sinaii Block

2. Sample examination

A total of 93 Cretaceous samples were examined in the present study. The samples had already been washed and prepared for picking. Each sample was split into four size fractions and picked as described in Chapter 4.

3. Biostratigraphy

The biostratigraphic conclusions in this section are based on the published results of El Naggar 1966, Pessagno 1967, Postuma 1971, Smith & Pessagno 1973, Sliter 1976, 1977 and Hart et al. 1981.

3.1. SITE 548A

3.1.1. Introduction

The drill site was located approximately 288 km SSW of the southernmost tip of Ireland, near to the end of the continental shelf (48°54,93'N, 12°09.87'W). About 551 m of sediments were penetrated, including 60 m of bioturbated chalk. The borehole bottomed in Hercynian quartzite.

3.1.2. Biostratigraphic conclusions

Sixteen samples were examined all of which yielded rich foraminiferal assemblages of moderate to good preservation, although recrystallisation and partial dissolution of the specimens was apparent and many of them were broken. The fauna was dominated by planktonic foraminifera; calcareous benthonic forms occurred sporadically while only rare specimens of agglutinated forms were recorded. The species present in the borehole together with their ranges are summarised in Fig. I.3.

SITE 548A

Core 35-1, 47-49cm	34-7, 27-29cm	34-4, 27-28cm	Core 34-1, 27-28cm	Core 33-1, 6-9cm	32-4, 78-80cm	32-3, 78-80cm	32-2, 78-80cm	Core 32-1, 78-78-80cm	31-3, 65-67cm	31-2, 65-67cm	Core 31-1, 65-67cm	30-3, 104-106cm	Core 30-1, 104-106cm	29-4, 70-72cm	Core 29-1, 70-72cm	SAMPLES / FAUNA
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Globotruncana arca
								●	●	●	●	●	●	●	●	Globotruncana contusa
				●	●	●	●	●	●	●	●	●	●	●	●	Globotruncana stuarti
										●	●	●	●		●	Abathomphalus mayaroensis
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Globotruncana stuartiformis
		●	●				●	●	●	●		●	●	●	●	Heterohelix spp.
				●	●				●			●		●	●	Bolivinoides draco
			●	●	●		●	●	●	●			●		●	Bolivina incrassata
●				●	●	●	●	●	●	●	●	●	●	●	●	Gavelinella pertusa
●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	Gyroidinoides nitida
●	●	●	●	●	●	●			●	●	●		●	●	●	Stensioeina pommerana
●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	Marssonella trochus
		●	●	●	●				●				●	●		Rugoglobigerina milamensis
		●	●	●	●				●			●	●	●		Rugoglobigerina rugosa
							●					●		●		Rugoglobigerina rotundata
●	●	●	●	●	●	●	●	●			●	●		●		Reussella szajnochae szajnochae
								●						●		Cibicides beaumontianus
	●			●	●	●		●			●	●	●	●		Pullenia quaternaria
									●	●		●	●	●		Racemigumbelina fructicosa
		●											●	●		Ataxophragmium variabile
	●										●		●			Praebulimina laevis
				●								●	●			Globotruncanella havanensis
●								●				●				Neoflabellina spp.
												●				Lenticulina spp.
●	●	●	●	●	●	●			●			●				Verneulina muensteri
●	●		●	●	●	●	●	●	●							Globotruncana patelliformis
●	●	●	●	●	●	●	●	●	●							Globotruncana linnieana
●	●	●	●	●	●	●	●		●							Globotruncana fornicata
●	●	●	●	●					●							Arenobulimina obliqua
●	●	●	●	●	●	●	●	●								Globotruncana ventricosa
●	●	●	●	●	●	●	●	●								Globotruncana bulloides
			●	●	●	●		●								Ventilabra spp.
	●						●									Globorotalites micheliniana
●	●	●	●	●	●											Globotruncana plummerae
●	●	●	●													Tritaxia tricarinata
			●													Bolivinoides laevigata
	●	●														Gaudryina laevigata
●	●															Praebulimina reussi
			●													Ammodiscus cretaceus

?	gansseri	mayaroensis	PLANKTONIC ZONE
?LATE CAMPANIAN - EARLY MAAS.	MIDDLE MAASTRICHTIAN	LATE MAASTRICHTIAN	AGE

Fig. I.3 Vertical distribution of foraminifera at Site 548A

The deepest samples examined from the borehole (Core 35 to Core 34-1, 27-29 cm) are dated as Late Campanian - Early Maastrichtian ('calcarata', 'aegyptiaca' or 'havanensis' zones). The fauna consists largely of planktonic species that are known to range throughout this interval, and included Globotruncana arca, G. bulloides, G. linneiana, G. patelliformis, G. stuartiformis and G. ventricosa, associated with the benthonic species with known similar ranges such as Bolivina incrassata, Bolivinoides laevigatus, Gyrodinoides nitida, Reussella szajnochae and Stensioeina pommerana. However, as key fossils are absent it is not possible to assign this part of the borehole to a particular zone.

The appearance of Globotruncana stuarti in Core 33-1, 6-9 cm marks the base of the 'gansseri' zone of Middle Maastrichtian age. The designated age is confirmed by the presence of G. bulloides, G. plummerae and G. ventricosa.

The last occurrence of Globotruncana fornicata, G. linneiana and G. patelliformis in Core 31-3, 65-67 cm and the subsequent appearance of Abathomaphalus mayaroensis in Core 31-2, 65-67 cm marks the base of the youngest Maastrichtian zone ('mayaroensis' zone). It is associated with the species Globotruncana arca, G. contusa, G. stuarti, G. stuartiformis and Racemiguembelina fructicosa, which are also characteristic of this zone. The age is endorsed by the presence of Bolivina incrassata, Bolivinoides draco and Stensioeina pommerana.

3.2. SITE 549

3.2.1. Introduction

The drill site was located approximately 69 km northwest of Site 548A (see above) (49°05.29'N, 13°05.88'W). About 1002m of sediments were penetrated which included 100 m of Middle Cenomanian to Maastrichtian grey-white chalk. The site is underlain by an 'Albian high' over which the Cenomanian strata 'thin'; the earliest Cenomanian is absent. Rapid subsidence and rising sea-level are believed to have caused the submergence of the Goban Spur from the Middle Cenomanian onwards and all the standard Upper Cretaceous stages are represented at this site.

3.2.2. Biostratigraphic conclusions

Ten samples from the latest Cretaceous were examined, all of which yielded rich foraminiferal assemblages. The faunas recovered were only moderately well preserved and many of the specimens were recrystallized and broken. Planktonic species were dominant whilst benthonic species (mainly calcareous) were generally rare and scattered. Agglutinated forms occurred only occasionally. The species present in this borehole together with their ranges are summarised in Fig.I.4.

The deepest samples examined from this borehole (Core 23-5, 130-133 cm to Core 22-5, 67-69 cm) are dated as Late Campanian - Early Maastrichtian ('calcarata', 'aegyptiaca' or 'havanensis' zones). The fauna includes planktonic species known to range throughout this interval such as Globotruncana arca, G. bulloides and G. linneiana, associated with the benthonic species Bolivina incrassata, Bolivinoides

SITE 549

Core 21cc	22-1, 46-48cm	22-2, 107-109cm	22-3, 105-109cm	22-4, 91-93cm	22-5, 47-49cm	Core 22,cc	23-1, 67-70cm	23-2, 49-52cm	Core 23-5, 130-133cm	SAMPLES / FAUNA
					●			●	●	Globotruncanella havanensis
●	●	●	●	●	●	●	●	●	●	Globotruncana arca
	●		●		●	●	●	●	●	Heterohelix spp.
				●	●				●	Rugoglobigerina rotundata
●	●	●	●	●	●	●	●	●	●	Globotruncana patelliformis
								●	●	Globotruncana contusa
					●	●		●	●	Globotruncana stuarti
		●	●	●	●	●		●	●	Globotruncana stuartiformis
								●	●	Racemigumbelina fructicosa
					●				●	Ventilabra spp.
									●	Pseudouvigerina rugosa
				●	●			●		Rugoglobigerina rugosa
				●	●		●	●		Rugoglobigerina milamensis
●			●					●		Eponides beisseli
●	●	●	●	●	●	●	●	●		Gyroidinoides nitida
	●	●	●		●	●		●		Pullenia quaternaria
				●				●		Pseudouvigerina cristata
	●		●	●	●	●		●		Globigerinelloides aspera
●	●			●		●	●	●		Marssonella trochus
●	●	●		●	●	●		●		Arenobulimina obliqua
●	●	●	●	●	●		●			Globotruncana linneiana
●	●	●	●	●	●		●			Globotruncana fornicata
●	●	●	●		●		●			Globotruncana ventricosa
●	●	●	●	●	●	●	●			Globotruncana bulloides
●	●	●		●		●	●			Reussella szajnochae szajnochae
●	●			●	●	●				Stensioeina pommerana
●		●		●	●	●				Praebulimina laevis
●	●	●	●	●	●					Globotruncana plummerae
●		●		●	●					Globorotalites hiltermanni
					●					Globigerinelloides multispina
		●			●					Praebulimina carseyae
	●	●	●		●					Bolivina incrassata
		●		●	●					Arenobulimina courta
			●	●						Praebulimina reussi
		●	●							Lenticulina spp.
		●								Bolivinoides laevigatus
●		●								Aragonia spp.
	●	●								Marssonella conoidea
?			gansseri		●					PLANKTONIC ZONE
										mayaroensis
?LATE CAMPANIAN-EARLY MAAS.			MIDDLE MAAS.		LATE MAAS.					AGE

Fig. I.4 Vertical distribution of foraminifera at Site 549

laevigatus, Praebulimina carseyae and P. reussi. However, as key fossils are absent it is not possible to assign this part of the borehole to a particular zone.

The appearance of Globotruncana stuarti in Core 22-4, 91-93 cm marks the base of the 'gansseri' zone, of Middle Maastrichtian age. The designated age is confirmed by the presence of the planktonic species G. bulloides, G. fornicata, G. linneiana, G. plummerae and G. ventricosa, associated with the benthonic species Bolivina incrassata, Gyroidinoides nitida and Stensioeina pommerana.

The last occurrence of G. bulloides, G. fornicata, G. linneiana and G. ventricosa in Core 22-2, 107-109 cm and the subsequent appearance of Globotruncana contusa, Globotruncanella havanensis and Racemigumbelina fructicosa in Core 22-1, 46-48 cm marks the base of the 'mayaroensis' zone (Late Maastrichtian). Although the key zonal fossil is absent, the age is endorsed by the associated presence of Globotruncana arca, G. stuarti and G. stuartiformis.

3.3. SITE 550B

3.3.1. Introduction

The drill site was located on the abyssal plain, 10 km southwest of the seaward edge of the Goban Spur (48°30.96'N, 13°26.32'W). About 720 m of sediment were penetrated including about 580 m of Cretaceous (Late Albian - Maastrichtian) turbiditic chalks. The borehole bottomed in a basalt with thin sediment intercalations.

3.3.2. Biostratigraphic conclusions

Forty-three samples of latest Cretaceous age were examined all of which yielded generally poor faunas which were badly preserved, recrystallized, often broken and had suffered from the effects of dissolution. Four samples were barren of microfauna. The samples were often small and yielded only small assemblages.

Deposition at the Cretaceous - Tertiary boundary seems to have been continuous; according to the shipboard results, the youngest Maastrichtian zones ('mayaroensis' (foraminifera) and 'murus' (nannoplankton)) are overlain by the oldest Danian zones ('eugubina' (foraminifera) and 'NP1' (nannoplankton)).

Of the 580 m of Cretaceous chalks, 104.8 m are ?Late Campanian - Maastrichtian. The thickness of chalk in this part of the succession can be attributed to rapid accumulation of turbiditic layers bringing shallow water organisms into a bathyal environment. The species present in this borehole together with their ranges are summarized in Fig.I.5.

The deepest samples examined from the borehole were from Core 12 and yielded very badly preserved and impoverished faunas. The calcareous benthonic element dominated the poor assemblages (except for Core 12 cc* where the planktonics dominated). The species recorded included Arenobulimina obliqua, Eponides beisseli, Marssonella trochus and Verneuilina muensteri. All these are known to be Campanian - Maastrichtian forms. A few specimens of Reussella szajnochae szajnochae were also recorded indicating a possible Late Campanian ('calcarata' zone) age.

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* = core catcher

SITE 550B

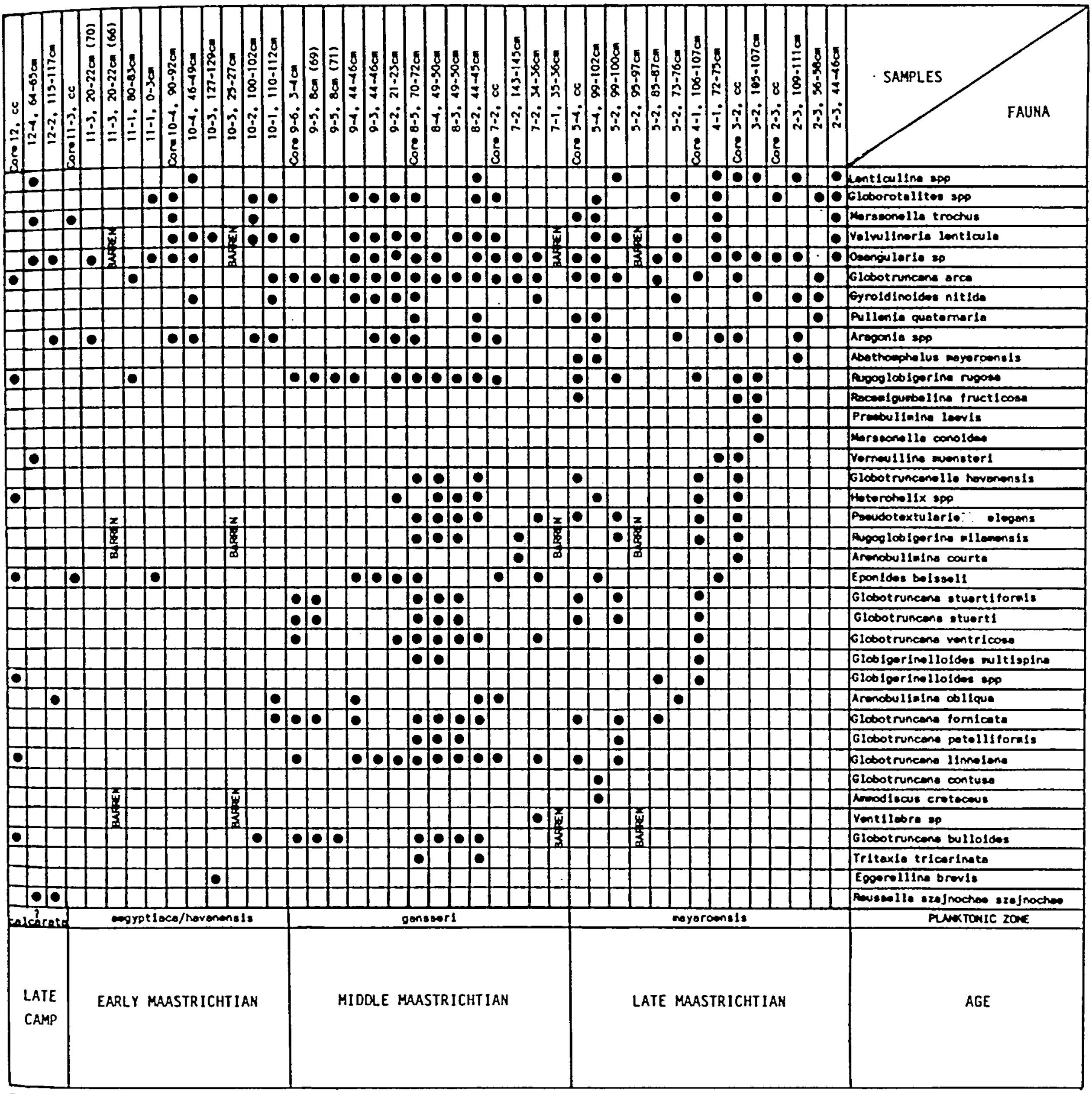


Fig. I.5 Vertical distribution of foraminifera at Site 550B

The Campanian - Maastrichtian boundary is tentatively placed between Core 12 and Core 11 where Reussella szajnochae szajnochae has its highest occurrence. The faunas from Core 11 and in the overlying Core 10 are very sparse and comprise mainly calcareous benthonic taxa. The fossils are badly preserved, broken and have suffered dissolution. Two samples from this interval (Core 11-3, 20-22 cm and Core 10-3, 25-27 cm) were barren. The species recorded from Cores 11 and 10 include Arenobulimina obliqua, Eponoides beisseli, Gyroidinoides nitida, Marssonella trochus, Pullenia quaternaria and Valvulineria lenticula. Planktonic forms were extremely rare in this interval and only two species - Globotruncana arca and G. fornicata - were recorded; these species are known to range throughout the latest Campanian and into the Maastrichtian. Because of the lack of age restricted taxa it is not possible to assign these cores to a particular zone, and an Early Maastrichtian age is suggested for this part of the section ('aegyptiaca' or 'havanensis' zones).

The appearance of Globotruncana stuarti in Core 9-6, 3-4 cm is taken to indicate the base of the 'gansseri' zone of Middle Maastrichtian age. The faunas in the samples from Core 9 are moderately well preserved and dominated by calcareous benthonic and planktonic taxa. Cores 9, 8 and 7 are assigned to the 'gansseri' zone on the basis of the planktonic assemblage of Globotruncana arca, G. bulloides, G. contusa, G. fornicata, G. linneiana, G. stuartiformis and G. ventricosa, associated with the benthonics Gyroidinoides nitida, Marssonella trochus, Pullenia quaternaria and Valvulineria lenticula.

The planktonics dominate the fauna in Core 8, but the calcareous benthonics become dominant in Core 7. The topmost sample of Core 7 (7-1, 33-36 cm) was barren.

The appearance of Abathomaphalus mayaroensis in Core 5-4, 99-102 cm (and in Core 4 cc) is taken to mark the base of the youngest Maastrichtian zone ('mayaroensis' zone), but the boundary is only tentatively placed here as the sample immediately below was barren. The presence above this of Globotruncana fornicata (Core 5-2, 99-100 cm and Core 5-2, 85-87 cm), G. linneiana (Core 5-2, 99-100 cm), G. patelliformis (Core 5-2, 99-100 cm) and G. ventricosa (Core 4-1, 106-107 cm), usually recorded as being Middle Maastrichtian in age ('gansseri' zone), also casts some doubt on the accurate placing of this boundary.

The faunas in Core 5-2 are moderately well preserved, but often broken and are dominated by calcareous benthonics. A Late Maastrichtian age ('mayaroensis' zone) is indicated by the association of Globotruncana contusa, Globotruncanella havanensis, Pseudotextularia elegans, Racemigumbelina fructicosa and Rugoglobigerina rugosa, with the benthonic species Praebulimina laevis and Pullenia quaternaria.

It is emphasized that carbonate dissolution is an important agent in modifying fossil assemblages at this site (particularly in Cores 12 to 9). As a result, it is difficult to make exact age determinations and all biostratigraphic conclusions are only tentative.

3.4. SITE 551

3.4.1. Introduction

The drill site was located approximately 424 km southwest of Cobh, Ireland and 40 km nolrth of Site 550 (see above) 48°54.64'N, 13°30.09'W). About 201 m of sediment were penetrated including 44 m of Cretaceous chalk; the borehole bottomed in basalt.

3.4.2. Biostratigraphic conclusions

The Cretaceous strata comprised two stratigraphic units separated by a distinct hiatus; the lower unit is dated as Late Cenomanian - Early Turonian (pers. comm. M.B. Hart), and the upper unit is dated as Late Campanian - Early Maastrichtian.

Twenty-four samples from the upper unit were examined, all of which yielded rich foraminiferal assemblages dominated by planktonic forms. The preservation was moderate to good, although many of the fossils were broken. Calcareous benthonic species occurred sporadically, and agglutinated forms were rare. The species present in this borehole together with their ranges are summarized in Fig. I.6.

In the present study, the deepest samples examined from the borehole (Core 4 cc to Core 4-1, 97-108 cm) are dated as probable Late Campanian ('calcarata' zone). This conclusion is based on the presence of the benthonic species Globorotalites hiltermanni and G. micheliniana. The planktonic species present in this interval are those which are known to range throughout the latest Campanian and into the Maastrichtian, and include Globotruncana bulloides, G. linneiana, G. plummerae and G. ventricosa. The key species - G. calcarata - is absent.

SITE 551

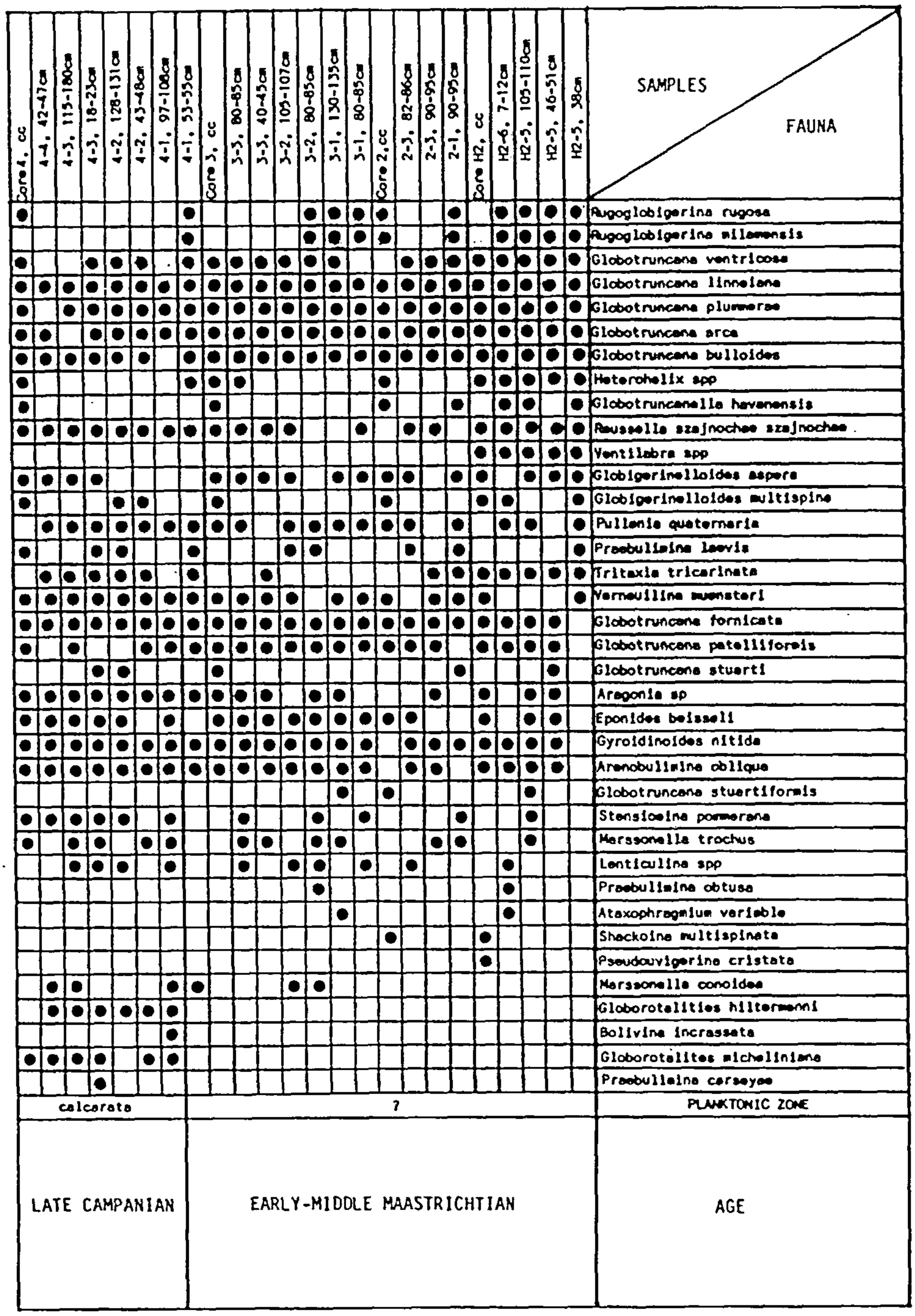


Fig. I.6 Vertical distribution of foraminifera at Site 551

The last occurrence of G. hiltermanni and G. micheliniana in Core 4-1, 53-55 cm is taken to mark the base of the Maastrichtian.

The remainder of the samples examined are dated as probable Early - Middle Maastrichtian. This conclusion is based on the associated occurrence of the planktonic species G. arca, G. bulloides, G. stuarti, G. stuartiformis and G. ventricosa, all of which are known to range throughout this interval. The designated age is confirmed by the occurrence of benthonic species including Eponides beisseli, Praebulimina obtusa and the agglutinated form Verneuilina muensteri.

4. Systematic descriptions

For taxa included in the range charts or cited in the text that have been discussed in Chapter 6, only brief taxonomic details are given. Additional taxa are dealt with in the way outlined previously, following the classification of Loeblich & Tappan (1964, amended 1974).

Order FORAMINIFERIDA Eichwald 1830

Suborder TEXTULAIINA Delage & Herouard 1896

Superfamily LITUOLACEA de Blainville 1825

Family ATAXOPHRAGMIIDAE Schwager 1877

Subfamily VERNEUILININAE Cushman 1911

Genus VERNEUILINA D'Orbigny 1839

Type species Verneuilina tricarinata d'Orbigny 1840

Verneuilina muensteri Reuss 1854

(Pl.26, Fig.1)

1854 Textularia triquetra (v. Munstr.) Reuss, p.39, pl.13, fig.77.

Genus TRITAXIA Reuss 1860

Type species Textularia tricarinata Reuss 1846

Tritaxia tricarinata (Reuss 1844)

(Pl.26, fig.2).

1844 Textularia tricarinata Reuss, p.215.

Subfamily GLOBOTEXTULARIINAE Cushman 1927

Genus ARENOBULIMINA Cushman 1957

Type species Bulimina preslii Reuss 1846

Arenobulimina obliqua (d'Orbigny 1840)

(Pl.26, fig.3)

1840 Bulimina obliqua d'Orbigny, p.40, pl.4, figs.7,8.

Genus MARSSONELLA Cushman 1933

Type species Textularia trochus d'Orbigny 1840

Marssonella conoidea (Marie 1941)

(Pl.26, fig.4a,b)

1941 Textularia conoidea Marie, p.63, pl.2, fig.20.

1953 " " Marie; Hagn, p.11, pl.1, fig.8.

1963 Marssonella conoidea (Marie); Barnard, pp.44-46, t.fig.4a-c.

Description: test free, initially rounded and generally bullet-shaped, initially expanding rapidly and uniformly in size but becoming gently expanding and almost parallel-sided; initially chambers arranged trochospirally in indistinct whorls with three to five chambers per whorl, but rapidly becoming biserial with ten to twelve pairs of chambers common; sutures distinct, depressed and obscured by the surface ornamentation; aperture a broad oval to subrectangular interiomarginal slit; wall coarsely arenaceous with spicular material making the surface rough and slightly spinose.

Remarks: this species was originally described by Marie (1941) from the Campanian of the Paris Basin. The type figures are very stylised but show clearly the characteristically blunt, bullet-shaped test and the spinose wall. It can be distinguished from Marssonella trochus 'turris form' (d'Orbigny 1840) by the less evenly flaring test and spinose surface. Swiecicki (1980 unpubl.) noted transitional forms between M. conoidea and M. trochus that had a less spicular wall and generally a more rugose surface.

Marssonella trochus (d'Orbigny 1840)

(Pl.26, fig.5a,b)

1840 Textularia trochus d'Orbigny p.45, pl.4, figs.25,26.

Subfamily ATAXOPHRAGMIINAE Schwager 1877

Genus ATAXOPHRAGMIUM Reuss 1860

Type species Bulimina variabilis d'Orbigny 1840

Ataxophragmium variabile (d'Orbigny 1840)

(Pl.26, fig.6a,b)

p.1840 Bulimina variabilis d'Orbigny, p.40, pl.4, figs.9,10, ?11 (non 12).

Suborder ROTALINA Delage & Herouard 1896

Superfamily BULIMINACEA Jones 1875

Family TURRILINIDAE Cushman 1927

Subfamily TURRILININAE Cushman 1927

Genus PRAEBULIMINA Hofker 1953

Type species Bulimina reussi Morrow 1934

Praebulimina laevis (Beissel 1891)

(Pl.27, fig.1a,b)

1891 Bulimina laevis Beissel, p.66, pl.12, figs.39-43.

Family BOLIVINITIDAE Cushman 1927

Genus BOLIVINA d'Orbigny 1839

Type species Bolivina plicata Cushman 1911

Bolivina incrassata Reuss 1851

(Pl.27, fig.1a,b)

1851 Bolivina incrassata Reuss, p.45, pl.4,(5) fig.13.

Genus BOLIVINOIDES Cushman 1927

Type species Bolivina draco Marsson 1878

Bolivinoides draco (Marsson 1878)

(Pl.27, fig.3)

1878 Bolivina draco Marsson, p.157, pl.3, fig.25.

Bolivinoides peterssoni Brotzen 1945

(Pl.27, fig.4)

1945 Bolivinoides peterssoni Brotzen, p.49, pl.1, fig.10.

1953 " " Brotzen; Wicker, pp.14-15, t.fig.1, fig.3.

1954 " " Brotzen; Reiss, p.157, pl.30, figs.12-14.

1955 _____" _____" Brotzen; Hiltermann & Koch, pp.366-367, pl.28, figs.7,8.

1957 _____" _____" Brotzen; Hofker, p.253, t.fig.312.

non1958 Bolivinoides peterssoni Brotzen; Witwicka, p.200, pl.9, fig.12.

1961 _____" _____" Brotzen; Vasilenko, pp.198-199, pl.40, fig.8.

1962 _____" _____" Brotzen; Hiltermann & Koch, p.317, pl.50, fig.16.

1966a_____" _____" Brotzen; Barr, pp.238-239, pl.38, fig.6.

1968 _____" _____" Brotzen; Stensted, pl.2, fig.2.

1970 _____" _____" Brotzen; Barr, p.650, pl.99, fig.6.

1977 _____" _____" Brotzen; Koch, p.59, pl.13, fig.6.

1981 _____" _____" Brotzen; Hart et al., in Jenkins & Murray, p.182, pl.7.5, fig.5.

Description: test free and elongate; periphery slightly lobate, cross section compressed and elliptical; proloculus globular followed by seven to eight pairs of biserial, slightly inflated oblique chambers; sutures distinct and depressed; aperture a narrow loop shaped opening extending up the apertural face; wall calcareous and perforate, surface strongly ornamented in the median portion of the test by elongate nodes, perpendicular to the sutures.

Remarks: this species was originally described from the Maastrichtian of Holviken (Brotzen 1945). It may be distinguished from its ancestoral B. laevigatus Marie 1941 by its broader and more compressed test and more restricted ornament.

Family BULIMINIDAE Jones 1875

Subfamily PAVONINAE Eimer & Fickert 1899

Genus REUSSELLA Galloway 1933

Type species Verneuilina spinulosa Reuss 1850

Reussella szajnochae szajnochae (Grzybowski 1896)

(Pl.27, fig.5)

1896 Verneuilina szajnochae Grzybowski, p.287, pl.9, fig.19.

Family UVIGERINIDAE Haeckel 1894

Genus PSEUDOUVIGERINA Cushman 1927

Type species Uvigerina cristata Marsson 1878

Pseudouvigerina cristata (Marsson 1878)

(Pl.27, fig.6 a,b)

1878 Uvigerina cristata Marsson, p.150, pl.3, fig.20.

Superfamily DISCORBACEA Ehrenberg 1838

Family EPONIDIDAE Hofker 1951

Genus EPONIDES De Montfort 1808

Type species Nautilus repandus Fitchel & Moll 1798

Eponides beisseli Schijfsma 1946

(Pl.27, fig.7 a,b)

1946 Eponides beisseli Schijfsma, p.84, pl.4, fig.13.

Family CIBICIDAE Cushman 1927

Subfamily CIBICIDINAE Cushman 1927

Genus CIBICIDES De Montfort 1808

Type species Cibicides refulgens De Montford 1808

Cibicides beaumontianus (d'Orbigny 1840)

(Pl.27, fig.8 a,b)

1840 Truncatulina beaumontiana d'Orbigny, p.35, pl.3, figs.17-19.

Cibicides ribbingi Brotzen 1936

(Pl.27, fig.9 a,b)

1936 Cibicides ribbingi Brotzen, pp.186-189, pl.13, figs.5,6, t.figs.67-68.
1946 " ribbingae Brotzen; Schijfsma, pp.101-102, pl.6, fig.6.
1948 " ribbingi Brotzen; Williams-Mitchell, p.103, pl.9, fig.5.
1956 " megaloperforatus Said & Kenawy, p.155, pl.7, fig.13.
1960 " ribbingi Brotzen; Belford, p.11, pl.34, figs.17-20.
1969 " ribbingae Brotzen; Hanzlikova, p.53, pl.14, fig.4.
1972 " ribbingi Brotzen; Hanzlikova, pp.116-117, pl.34, fig.4.
1973 " " Brotzen; Koch, pp.211-212.
1981 " " Brotzen; Hart et al., in Jenkins & Murray,

p.184, pl.7.6, figs.1,2.

Description: test attached, plano-convex with the dorsal side flattened and the ventral side weakly inflated; outline extremely variable and in later chambers may become irregular; margin acutely angled; chambers distinct, broadly flattened and weakly inflated ventrally, five to seven in the final whorl; sutures slightly depressed, straight and radial ventrally, indistinct and flush dorsally; aperture a slit on the inner margin of the final chamber extending round towards the umbilicus; umbilicus shallow; surface smooth.

Remarks: this species was originally described from the Lower Senonian of Eriksdal, Sweden (Brotzen 1936). Barr (1966b) regarded this species as an ecophenotype of C. beaumontianus (d'Orbigny); this is not supported by Bailey (1978 (unpubl.)), Swiecicki (1980 (unpubl.)) or Hart et al. (1981) as slightly different stratigraphic ranges have been recorded for the two species and no transitional forms between the two have been recorded.

Superfamily GLOBIGERINACEA Carpenter, Parker & Jones 1862

Family HETEROHELICIDAE Cushman 1927

Subfamily HETEROHELICINAE Cushman 1927

Genus RACEMIGUEMBELINA Gallitelli 1957

Type species Guembelina fructicosa Egger 1899

Racemiguembelina fructicosa (Egger 1899)

(Pl.28, fig.1 a,b)

p1895 Pseudotextularia varians Rzehak, p.217, pl.7, figs.2,3,
non 1a,b.

p1899 Gumbelina fructicosa Egger, p.35, pl.14, figs.8,9,
non 24-26.

p1899 " acervulinoides Egger, p.36, pl.14, fig.20?,
non 14-18, 21-22.

1929 Pseudotextularia varians Rzehak; White, p.40, pl.4, fig.15 a-b

1929 " " Rzehak var. mendezensis White, p.41,
pl.4, fig.16 a,b.

p1938 " " Rzehak, pp.21-22, pl.4, fig.1 a,b, 4,
non 2a-b, 3a-b.

p1946 " " Rzehak; Cushman, p.110, pl.47,
figs.4a-b?, 6, 9a-b,
non 5a-b, 7a-b.

1948 " " Rzehak; Kikoine, p.23, pl.2,
figs.4a-c.

non1957 " fructicosa (Egger); Gallitelli, pp.142-143,
pl.32, figs.14a,b, 15a,b.

non1962 " " (Egger); Berggren, pp.22-24,
pl.6, fig.6a,b.

non1964 Racemigumbelina fructicosa (Egger); Loeblich & Tappan, p.C656,
fig.525, (8a-b).

non1967 " " (Egger); Pessagno, p.270, pl.90,
figs.14,15.

non1969 " " (Egger); Pessagno & Brown, p.116,
pl.1, figs.1-4.

pl.1, figs.1-4.

1973 ____"____"____ (Egger); Smith & Pessagno, pp.33-35 pl.12, figs.1-8.

Description: test free and conically shaped; initially biserial with development of supplementary chambers in the later stages; cross section circular to oval and composed of a varying number of globular supplementary chambers; chambers initially indistinct and flattened and increasing gradually in size as added; terminal chambers may be smaller than the preceeding chambers; sutures initially flush, becoming depressed and curved; each terminal chamber has a basal, wide and highly arched aperture opening into the central cavity of the test and maybe covered by ponticuli; surface heavily rugose with closely spaced, massive costellae, arranged vertically on the chamber surfaces.

Remarks: in 1895 (p.217) Rzehazk first described Pseudotextularia varians from the Upper Cretaceous of the Bavarian Alps in Germany (no type locality or horizon designated). His description included both biserial and multiserial forms and his synonymy included the earlier described Cuneolina elegans Rzehak 1891, thereby invalidating Pseudotextularia varians as a junior synonym (Ellis & Messina 1940; Gallitelli 1957; Smith & Pessagno 1973). In 1929, White referred the biserial forms to P. elegans and incorrectly retained P. varians for the multiserial forms described by Rzehak. The earliest valid name for the many chambered forms is Guembelina fructicosa Egger 1899. Pessagno (1967 p.270) designated Egger's figures 8 and 9 (1899, pl.14) as the lectotype.

This species has been recorded from the Maastrichtian of Texas (eg. Cushman 1926; White 1929; Smith & Pessagno 1973), Cuba (eg. Seiglie 1959), France (eg. Dupeuble 1969), Mexico (eg. Smith & Pessagno 1973), and Trinidad (eg. Smith & Pesagno 1973). All available records thus indicate this species to be a distinctive and important guide fossil for the Middle to Late Maastrichtian.

Family PLANOMALINIDAE Bolli, Loeblich & Tappan 1957

Genus GLOBIGERINELLOIDES Cushman & Ten Dam 1948

Type species Globigerinelloides algeriana Cushman & Ten Dam 1948

Globigerinelloides multispina (Lalicker 1948)

(Pl.28, fig.2a,b)

1948 Biglobigerinella multispina Lalicker, p.5, pl.92, figs.1-3.

Family SCHACKOINIDAE Pokorny 1958

Genus SCHACKOINA Thalman 1932

Type species Siderolina cenomana Schacko 1932

Schackoina multispinata (Cushman & Wickenden 1930)

(Pl.28, fig.3)

1930 Hantkenina multispinata Cushman & Wickenden, p.40, pl.6, figs.4-6.

1933 Schackoina " (Cushman & Wickenden); Cushman, pl.35, figs.9,10.

1934 Hantkenina trituberculata Morrow, p.195, pl.29, figs.24,26-28.

1946 Schackoina multispinata (Cushman & Wickenden); Cushman, p.148, pl.61, figs.11,12.

1946 " trituberculata (Morrow); Cushman, p.148, pl.61, figs.13-16.

1961 " multispinata (Cushman & Wickenden); Loeblich & Tappan, pp.271-272, pl.1, figs.8-10.

1967 " " (Cushman & Wickenden); Pessagno, p.280, pl.60, fig.1.

Description: test free, small, low trochospire; chambers distinct but few in number and rapidly increasing in size as added, subglobular to radial, elongate with three (rarely four) in the final whorl, with an elongate radial tubulospine extending from the median portion of each chamber; sutures distinct, depressed and strongly constricted; aperture interiomarginal and equatorial with a narrow, bordering lip.

Remarks: this species was originally described from the Cheval Formation of Manitoba (Upper Cretaceous) (Cushman & Wickenden 1930) and has since been recorded from Texas, Kansas and California (Loeblich & Tappan 1961); it is also common in the Upper Cretaceous of Europe (Pessagno 1967).

Schackoina trituberculata Morrow was first described from Kansas (1934). After examining the holotype, Loeblich & Tappan (1961) concluded it to be identical with S. multispinata; S. trituberculata

is thus a junior synonym.

Family GLOBOTRUNCANIDAE Brotzen 1942

Subfamily GLOBOTRUNCANINAE Cushman 1926

Genus GLOBOTRUNCANA Cushman 1926

Type species Pulvinulina arca Cushman 1926

Globotruncana arca (Cushman 1926)

(Pl.29, fig.1a,b,c)

1926b Pulvinulina arca Cushman, p.23, pl.3, fig.1.

Globotruncana bulloides Vogler 1941

(Pl.29, fig.2a,b,c)

1941 Globotruncana linnei (d'Orbigny) subsp. bulloides Vogler, p.287, pl.23, figs.29-32.

Globotruncana contusa (Cushman 1926)

(Pl.29, fig.3a,b,c)

1926 Pulvinulina arca var. contusa Cushman, p.23.

Globotruncana fornicata Plummer 1931

(Pl.30, fig.1a,b,c)

1931 Globotruncana fornicata Plummer, pp.198-199, pl.13, figs.4,5,6.

1936 " " Plummer; Jennings, p.37, pl.4, fig.13.

1946 " " Plummer; Cushman, p.149, pl.61, fig.19.

1953 " " Plummer; Hagn, p.98, pl.8, fig.8.

1953 " " Plummer; Subbotina, pp.184-185, pl.8, figs.3-5.

1955 " " fornicata Plummer; Gandolfi, p.40, pl.2, fig.2.

1955 " " manaurensis Gandolfi, p.41, pl.2, fig.1.

1958 " " Plummer; Witwicka, pp.220-221, pl.17, fig.32.

1961 " " Plummer; Vasilenko, pp.154-156, pl.33, fig.3.

1963 " " Plummer; van Hinte, p.61, pl.1, figs.1-2, pl.20, fig.3.

1964 " " Plummer; Olsson, pp.165-166, pl.2, figs.3,4, pl.3, figs.7,8.

1966 " " fornicata Plummer; El-Naggar, pp.105-8, pl.13, figs.5,6.

1967 " " Plummer; Pessagno, pp.338-341, pl.63, figs.1-9, pl.80, figs.7-9, pl.96, figs.3-4 (full synonomy).

1968 " " Plummer; Sliter, p.103, pl.16, figs.5-7.

1969 " " Plummer; Douglas, p.179, pl.7, fig.6.

1971 " " Plummer; Postuma, pp.16-17, pl.12,

figs.1-7.

1972 ___"___ ___"___ Plummer; Hanzlikova, p.106, pl.28, figs.6-7.

1977 ___"___ ___"___ Plummer; Masters, pp.564-566, pl.44, figs.4-6.

1981 ___"___ ___"___ manaurensis Gandolfi; Frerichs & Dring, p.69, pl.5, figs.7-9.

1981 ___"___ ___"___ fornicata Plummer; Frerichs & Dring, p.69, pl.5, figs.13-15.

1981 ___"___ ___"___ Plummer; Hart et al., in Jenkins & Murray, pp.200-201, pl.7.14, figs.8-10.

1984 Rosita fornicata (Plummer); Robaszynski et al., pp.250,301, pl.38, figs.1-5.

Description: test free, moderate trochospire, asymmetrically biconvex; equatorial periphery truncated by two well spaced keels; chambers distinct, elongate and subrectangular umbilically, elongate and crescent-shaped spirally with four to five in the final whorl; sutures distinct, raised, beaded and strongly curved umbilically, raised, beaded and arched spirally; primary aperture interiomarginal and umbilical; umbilicus narrow and deep and covered by a tegilla.

Remarks: this species was originally described from the Upper Taylor Marl (Campanian) of Texas (Plummer 1931),and can be distinguished by its moderately convex spiral side and elongate crescentric chambers.

Globotruncana linneiana (d'Orbigny 1839)

(Pl.30, fig.2a,b,c)

1839 Rosalina linneiana d'Orbigny, p.110, pl.5, figs.10-12.

Globotruncana patelliformis Gandolfi 1955

(Pl.30, fig.3a,b,c)

p1955 Globotruncana contusa (Cushman); Troelsen, pp.80-81, t.fig.2d-f, g, non t.fig.2a-c.

1955 " " patelliformis Gandolfi; pp.54-55, pl.4, fig.2a-c.

1960 " " (Cushman); Olsson, p.50, pl.10, figs.25,26.

1963 " (Globotruncana) plicata calciformis Vogler; van Hinte, p.64, pl.3, figs.2a-c.

p1964 " contusa (Cushman); Olsson, pp.163-164, pl.2, figs.5a-c, pl.3, figs.9a-c, non pl.3, figs.6a-c.

1966 " adamsi El-Naggar, pp.75-76, pl.8, fig.2a-d.

1966 " contusa patelliformis Gandolfi; El-Naggar, pp.93-95, pl.8, fig.1a-c.

p1967 " " (Cushman); Pessagno, pp.330-333, pl.75, figs.18-20, pl.77, figs.1-3, pl.96, figs.11,13, non pl.77, figs.4-6, non pl.78, figs.6-8 9-11, non pl.92, figs. 10-12, non pl.96, figs.14-16.

1969 " " (Cushman); Dupeuble, pp.154-155, pl.1,

figs.2a-c.

1973 " patelliformis Gandolfi; Smith & Pessagno, pp.50-51, pl.21, figs.6-8.

1984 Rosita patelliformis (Gandolfi); Robaszynski et al., p.252, pl.39, figs.1-3.

Description: test free, moderate trochospire of two to two and a half whorls; asymmetrically biconvex; outline circular, equatorial periphery truncated by two widely spaced keels; chambers distinct, elliptical to subrectangular umbilically, elongate and crescentric spirally with five to seven in the final whorl; sutures distinct, curved and slightly raised umbilically, curved and highly beaded spirally; primary aperture interiomarginal and umbilical; umbilicus narrow and deep and covered by a tegilla.

Remarks: Troelsen (1955, p.80) described two forms of Globotruncana contusa (Cushman 1926) from the Mastrichtian Kjolby Gaard Marl of Denmark. The 'typical' form he noted as being high-spired with deep plications on the spiral surface of its chambers, whilst the other 'variety' was smaller, lower-spired and lacked plications spirally. The second 'variety' was included in G. contusa because it was observed to grade into the plicate form. This was also noted by Berggren (1962). Gandolfi (1955) noted similar variation in his investigation of the Colon Shale (Maastrichtian) of Columbia, and named the smaller, higher spired and non-plicate form G. contusa patelliformis, whilst retaining the name G. contusa contusa for the larger plicate form.

G. patelliformis Gandolfi differs from G. contusa (Cushman) by being smaller, having a more circular peripheral outline rather than being polygonal and undulating, by being less convex spirally and lacking plications on the spiral side. G. patelliformis is closely related to G. contusa and probably gave rise to it during the late Middle Maastrichtian.

Globotruncana plummerae Gandolfi 1955

(Pl.30, fig.4a,b,c)

1955 Globotruncana fornicata plummerae Gandolfi, p.42, pl.2, figs.3,4.

1963 " (Globotruncana) fornicata plummerae Gandolfi; van Hinte, pp.63-64, pl.3, fig.1.

1966 " fornicata cesarensis Gandolfi; El-Naggar, pp.103-105 pl.13, figs?3a-c, 4a-c, fig.6a-c.

1966 " " globulocamerata El-Naggar, pp.108-109, pl.14, figs.1a-c, 2a-c, ?pl.13, fig.1a-c.

1967 " plummerae Gandolfi; Pessagno, pp.351-352, pl.66, figs.3-8.

1973 " " Gandolfi; Smith & Pessagno, p.51, pl.21, figs.9-11.

1977 " " Gandolfi; Rodriguez, pp.232-234, pl.36, figs.1,2.

1981 " " Gandolfi; Hart et al., in Jenkins & Murray, pp.202-203, pl.7.15, figs.3-5.

1984 Rosita plummerae (Gandolfi); Robaszynski et al., pp.256, 302, pl.41, figs.1-6.

Description: test free, low trochospire of two to two and a half whorls; asymmetrically biconvex; equatorial periphery truncated by two well developed, widely spaced keels; chambers distinct, elongate, subrectangular and weakly inflated umbilically, elongate, crescentric and inflated spirally, with four to five, rapidly increasing chambers in the final whorl; sutures distinct, depressed and curved; primary aperture interiomarginal and umbilical; umbilicus narrow and deep and covered by a tegilla.

Remarks: this species was originally described from the Colon Formation (Maastrichtian) of Columbia (Gandolfi 1955). It can be distinguished by its elongate, inflated chambers, with those of the final whorl increasing rapidly in size as added.

Globotruncana stuarti (de Lapparent 1918)

(Pl.31, fig.1a,b,c)

1918 Rosalina stuarti de Lapparent, p.11, pl.1, ?figs.5,6,7, t.figs.4,5a,b,?c.

non1936 Globotruncana stuarti (de Lapparent), pl.6, figs.35-41, pl.8, fig.4.

non1941 " linnei stuarti Vogler, p.289, pl.24, figs.8-13.

non1941 " stuarti (de Lapparent); Vogler, p.289, pl.23, figs.40-41.

pl1945 " " (de Lapparent); Bolli, p.236, pl.19,

fig.18, non t.fig.1,
figs.27,?28.

p1950 ___" (Globotruncana) stuarti (de Lapparent); Reichel,
pp.613-615, pl.16, fig.10,
pl.17, fig.10, non t.fig.7a.

1952 ___" falsostuarti Sigal, p.43, t.fig.46.

non1953 ___" stuarti (de Laparent); Subbotina, p.201, pl.15,
figs.3a-5c.

1955 ___" (Globotruncana) stuarti (de Lapparent); Dalbiez,
p.170, t.figs.4a-c.

non1955 ___" stuarti stuarti (de Lapparent); Gandolfi, p.64,
pl.5, figs.6a-c.

non1956 Marginotruncana stuarti (de Lapparent); Hofker, pp.332-333,
t.fig.23.

1962 Globotruncana (Globotruncana) stuarti (de Lapparent); Berggren,
pp.60-64, pl.10, figs.2a-c.

1962 ___" (") stuarti stuarti (de Lapparent);
Pessagno, pl.2, figs.1-3.

non1964 ___" stuarti stuarti (de Lapparent); Olsson, pp.58-60,
pl.8, figs.9a-c.

1967 ___" ___" (de Lapparent); Pessagno, pp.356-357,
pl.81, figs.1-6, pl.93,
figs.9-11, pl.94, fig.7.

1971 ___" ___" (de Lapparent); Postuma, pp.60-61.

1984 Globotruncanita stuarti (de Lapparent); Robaszynski et al.,
p.234, pl.30, figs.1-3,
pl.31, figs.1-3.

Description: test free, trochospire of two and a half whorls; spiroconvex, occasionally biconvex; outline subcircular and lobate, with the equatorial periphery marked by a sharply angled, single keel; chambers distinct, subrectangular umbilically, trapezoidal to crescent-shaped (typically trapezoidal) spirally with six to seven in the final whorl; sutures distinct, straight to slightly curved, raised and beaded; primary aperture interiomarginal and umbilical; umbilicus small, surrounded by prominent beaded umbilical shoulder, covered by a tegilla.

Remarks: G. stuarti (de Lapparent) is the earliest name applied to a single-keeled Campanian and Maastrichtian species of Globotruncana and earlier workers included all the single-keeled species under this name. Three separate species are now recognised - G. elevata (Brotzen 1934), G. stuartiformis Dalbiez 1955, and G. stuarti - all probably arising from G. stuartiformis (Pessagno 1967). G. stuarti can be distinguished from G. stuartiformis by its trapezoidally shaped, spiral chambers.

Globotruncana stuartiformis Dalbiez 1955

(Pl.31, fig.2a,b,c)

1955 Globotruncana (Globotruncana) elevata stuartiformis Dalbiez, p.169, t.fig.10a-c.

1955 " stuarti stuarti (de Lapparent); Gandolfi, pp.64-65, pl.5, fig.6a-c.

1955 " " parva Gandolfi; p.65, pl.5, fig.7a-c.

1962 " (Globotruncana) stuarti stuartiformis Dalbiez;

Pessagno, p.362, pl.2,
figs.4-6.

1962 " (") stuarti subspinosa Pessagno;
Pessagno, p.362, pl.2,
figs.7-9.

pl1963 " (") elevata subspinosa Pessagno;
van Hinte, p.71, pl.3,
fig.3a-c, non pl.4, fig.1a-c.

non1963 " (") elevata stuartiformis Dalbiez;
van Hinte, p.68, pl.1, fig.3.

1964 " stuarti stuarti (de Lapparent); Olsson, pp.169-70
pl.5, fig.9a-c.

non1964 " " stuartiformis Dalbiez; Olsson, p.170,
figs.6a-c, 8a-c.

1966 " " " Dalbiez; El-Nagger,
pp.136-139, pl.9, fig.3a-d.

1966 " " parva Gandolfi; El-Nagger, pp.131-133,
pl.9, fig.2a-d.

1966 " " subspinosa Pessagno; El-Nagger, pp.139-40
pl.10, figs.2a-c, 3a-c.

1967 " stuartiformis Dalbiez; Pessagno, pp.357-359,
pl.80, figs.3-6,
(G. stuartiformis trans. to
G. elevata); pl.92, figs.1-3
pl.93, figs.6,7, t.figs.43,
44, 17.

1969 " stuarti stuartiformis Dalbiez; Funnell et al.,
pp.34-35, pl.4, figs.10-12,
t.fig.18a-c.

1969 " " (de Lapparent); Funnell et al., pp.33-34, pl.4, figs.7-9, t.fig.17a-c.

1972 " stuartiformis Dalbiez; Barr, p.25, pl.6, fig.4a-c

1973 " " Dalbiez; Smith & Pessagno, pp.52-54 pl.19, figs.10-12.

1984 Globotruncanita stuartiformis (Dalbiez); Robaszynski et al., p.238, pl.32, figs.1-4.

Description: test free, trochospire of two and a half whorls, almost equally biconvex; outline subcircular and lobate, with the equatorial periphery marked by a sharply angled, sigmoidal single keel; chambers distinct, subrectangular to subtriangular umbilically, subtriangular to crescent shaped spirally with six to seven in the final whorl; sutures distinct, straight to curved, raised and beaded; primary aperture interiomarginal and umbilical; umbilicus large and deep, bordered by an umbilical shoulder which may be beaded, covered by a tegilla.

Remarks: this species was originally described from the Campanian of northwestern Tunisia (Dalbiez 1955). It is possible that G. stuartiformis gave rise to G. elevata (Brotzen 1934) during the Late Campanian, and G. stuarti (de Lapparent 1918) during the Middle Maastrichtian (Pessagno 1967). G. stuartiformis maybe distinguished from G. elevata by its more nearly biconvex test and by having subtriangular (rarely crescent shaped) rather than petaloid to crescent shaped chambers spirally. G. stuarti is also closely related to G. stuartiformis, but G. stuarti is characterised externally by possessing trapezoidally shaped, spiral chambers.

Globotruncana ventricosa White 1928

(Pl.31, fig.3a,b,c)

1928 Globotruncana canaliculata var. ventricosa White, p.284, pl.38, fig.5.

non1931 " " ventricosa White; Plummer, p.199, pl.13, fig.10.

non1936 " ventricosa White; Brotzen, pp.171-177, pl.13, fig.4, t.fig.63.

1946 " " White; Cushman, p.150, pl.62, fig.3.

1957 " (Globotruncana) paraventricosa (Hofker); Edgell, p.114, pl.1, figs.1-3.

1957 " ventricosa White; Bolli, p.57, pl.13, fig.4.

1962 " cf. ventricosa White; Barr, pp.577-578, pl.71, fig.2.

1966 " ventricosa White; Douglas & Sliter, p.115, pl.3, fig.1.

1967 " " White; Pessagno, pp.362-364, pl.75, figs.21-26, pl.79, figs.9-14, pl.95, figs.10-11, pl.99, fig.2.

1967 " " White; Bandy, p.20, t.fig.9, no.9.

1968 " " White; Barr, p.319, pl.40, fig.3.

pl1968 " " White; Sliter, p.107, pl.18, fig.7, non fig.8.

1971 " " White; Postuma, p.64, pl.26, figs.1-7.

1972 " " White; Hanzlikova, p.113, pl.31, figs.5-7.

1972 ____"____"____ White; Caron, p.555, pl.2, fig.3.

non1973 ____"____"____ White; Sliter, pl.4, figs.1-3.

1977 ____"____"____ White; Masters, pp.614-615, pl.55, figs.1-3.

1977 ____"____"____ White; Rodriguez, pp.265-272, pl.31, figs.2,3, pl.32, figs.1,2.

1984 ____"____"____ White; Robaszynski et al., pp.214-216, pl.20, figs.1-3.

Description: test free, robust, low trochospire of two and a half to three whorls, weakly biconvex; outline subcircular and lobate, with the equatorial periphery truncated by two closely spaced, heavily beaded keels; chambers distinct, inflated, highly convex and subrectangular umbilically, petaloid and flattened spirally, with six to seven in the final whorl and gradually increasing in size as added; sutures distinct, weakly depressed and curved umbilically, raised, curved and beaded spirally; primary aperture interiomarginal and umbilical, umbilicus deep and bordered by a beaded umbilical shoulder, covered by a tegilla.

Remarks: this species was originally described from the Upper Campanian of Mexico (White 1928). It is a distinctive species characterised by its robust, almost planoconvex test and closely spaced keels.

Subfamily GLOBOTRUNCANELLINAE Maslakova 1964

Genus ABATHOMPHALUS Bolli, Loeblich & Tappan 1957

Type species Globotruncana mayaroensis Bolli 1951

Abathomphalus mayaroensis (Bolli 1951)

(Pl.28, fig.5a,b,c)

1951 Globotruncana mayaroensis Bolli, p.198, pl.35, figs.10-12.

Genus GLOBOTRUNCANELLA Reiss 1957

Type species Globotruncana citae Bolli 1951 (= G. havanensis Voorwijk 1937)

Globotruncanella havanensis (Voorwijk 1937)

(Pl.28, fig.4a,b,c)

1937 Globotruncana havanensis Voorwijk, p.195, pl.1, figs.25,26,29.

Genus RUGOGLOBIGERINA Brönnimann 1952

Type species Globigerina rugosa Plummer 1927

Rugoglobigerina rugosa (Plummer 1927)

(Pl.32, fig.1a,b,c)

1927 Globigerina rugosa Plummer, pp.38-39, pl.2, fig.10.

Rugoglobigerina milamensis Smith & Pessagno 1973

(Pl.32, fig.2a,b,c)

1957 Rugoglobigerina rugosa (Plummer); Edgell, pp.116-118, pl.4, figs.10-12.

1973 " milamensis Smith & Pessagno, pp.56-57, pl.24, figs.4-7.

Superfamily NONIONACEA Schultze 1854

Family NONIONIDAE Schultze 1854

Subfamily NONIONINAE Schultze 1854

Genus PULLENIA Parker & Jones 1862

Type species Nonionina bulloides d'Orbigny 1846

Pullenia reussi Cushman & Todd 1943

(Pl.33, fig.1a,b)

1943b Pullenia reussi Cushman & Todd, pp.4-5, pl.1, figs.10-13.

Genus GYROIDINOIDES Brotzen 1942

Type species Rotalia nitida Reuss 1844

Gyroidinoides nitida (Reuss 1844)

(Pl.33, fig.2a,b,c)

1844 Rotalia nitida Reuss, p.214.

Family ANOMALINIDAE Cushman 1927

Genus GAVELINELLA Brotzen 1942

Type species Discorbina pertusa Marsson 1878

Gavelinella pertusa (Marsson 1878)

(Pl.33, fig.3a,b,c)

1878 Discorbina pertusa Marsson, p.166, pl.4, fig.35.

Genus STENSIOEINA Brotzen 1936

Type species Rotalia exsculpta Reuss 1860

Stensioeina pommerana Brotzen 1936

(Pl.33, fig.4a,b,c)

1936 Stensioeina pommerana Brotzen, p.166.

PLATES

Plate 1

1. Ammodiscus cretaceus (Reuss), NS/009, 44/2-1, 3,180', x62

2. Vernuelina muensteri (Reuss), NS/046, 49/19-1, 2,390', x87

3. Vernuelina sp. A. NS/059, 44/2-1, 4,850', x113

4. Gaudryina laevigata Franke, NS/036, 49/19-1, 1,740', x38

5. Gaudryina rugosa d'Orbigny, NS/056, 49/19-1, 2,360', x113

6. Tritaxia tricarinata (Reuss), NS/111, 49/19-1, 1,970'

   (a) side view x80

   (b) apertural view x87

7. Arenobulimina advena (Cushman), NS/084, 44/2-1, 5,000', x120

8. Arenobulimina anglica Cushman, NS/080, 49/20-2, 6,610', x107

9. Arenobulimina anglica Cushman, NS/083, 49/20-2, 6,610', x68

Plate 1

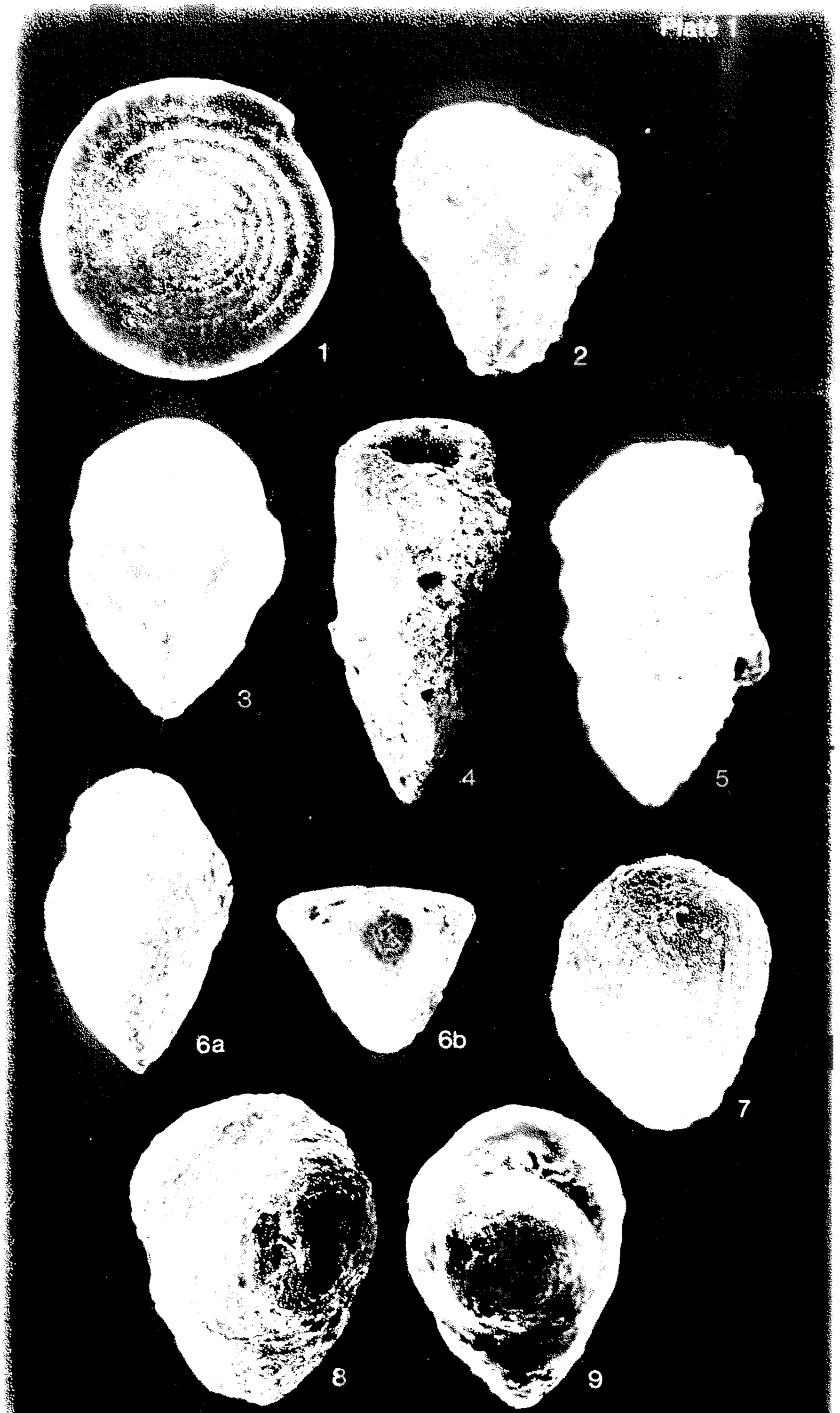


Plate 2

1. Arenobulimina courta (Marie), NS/020, 49/20-2, 3,500', x73

2. Arenobulimina elevata (d'Orbigny), NS/017, 49/19-1, 1,710', x57

3. Arenobulimina footei Jennings, NS/018, 49/19-1, 1,650', x120

4. Arenobulimina obliqua (d'Orbigny), NS/013, 49/19-1, 1,940', x93

5. Arenobulimina puschi (Reuss), NS/027, 49/19-1, 1,650', x127

6. Dorothia pupa (Reuss), NS/085, 44/2-1, 4,200'

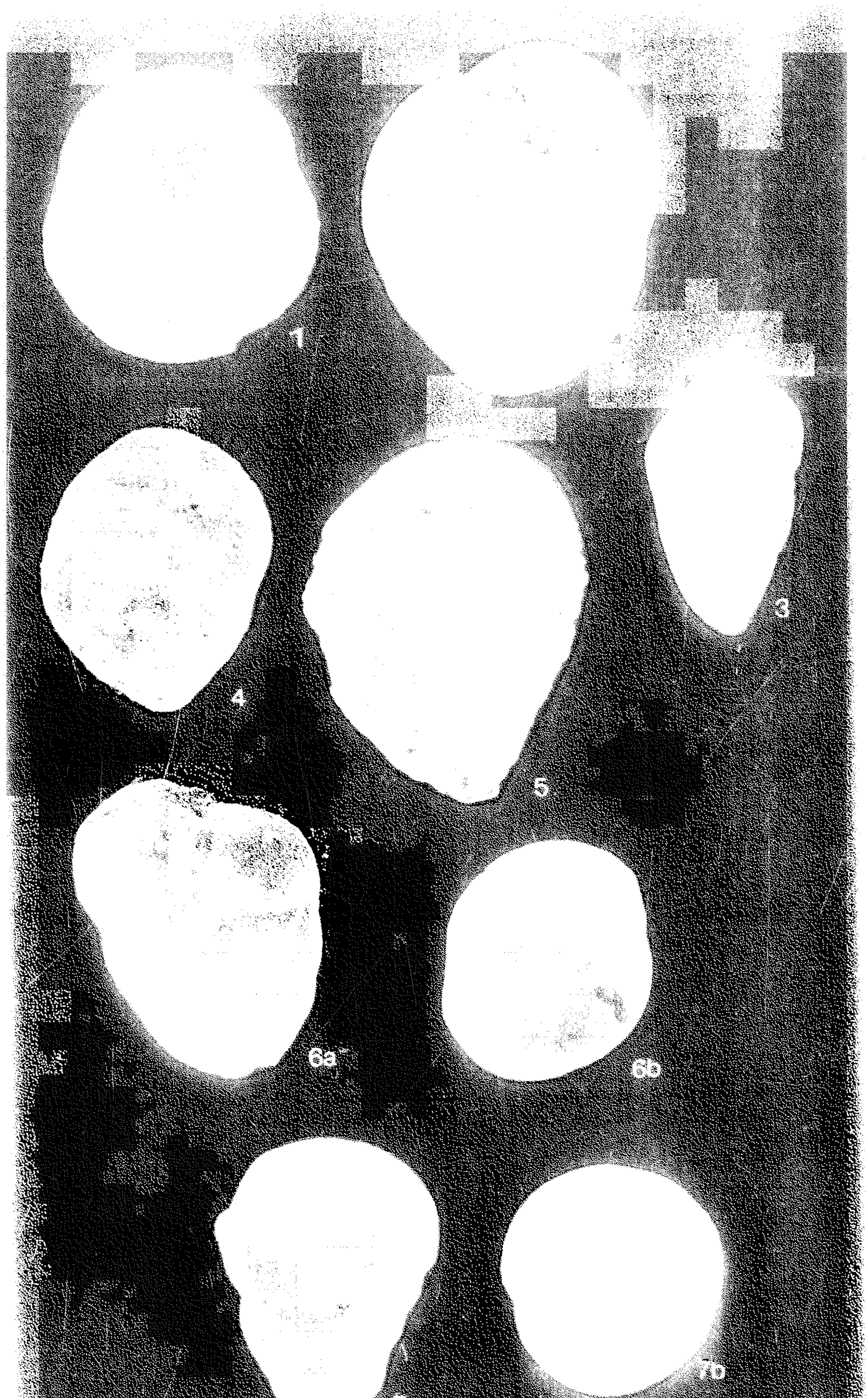
   (a) side view x78

   (b) apertural view x78

7. Marssonella trochus (d'Orbigny), NS/045, 49/19-1, 2,480'

   (a) side view x107

   (b) apertural view x107


1
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6a
6b
7a
7b

Plate 3

1. Eggerellina brevis (d'Orbigny), megalospheric form, NS/037, 49/19-1, 1,740'

(a) apertural view x47

(b) side view x47

2. Eggerellina brevis (d'Orbigny), microspheric form, NS/033, 49/19-1, 1,740'

(a) apertural view x57

(b) side view x58

3. Eggerellina mariae ten Dam, NS/086, 49/20-2, 6,610', x 160

4. Plectina cenomana Carter & Hart, NS/103, 49/20-2, 6,610', x107

5. Reophax sp. NS/081, 49/20-2, 6,610'

(a) apertural view x 167

(b) side view x167

6. Ataxophragmium sp. A. sp. nov. NS/048, 49/20-2, 3,020'

(a) apertural view x52

(b) side view x52

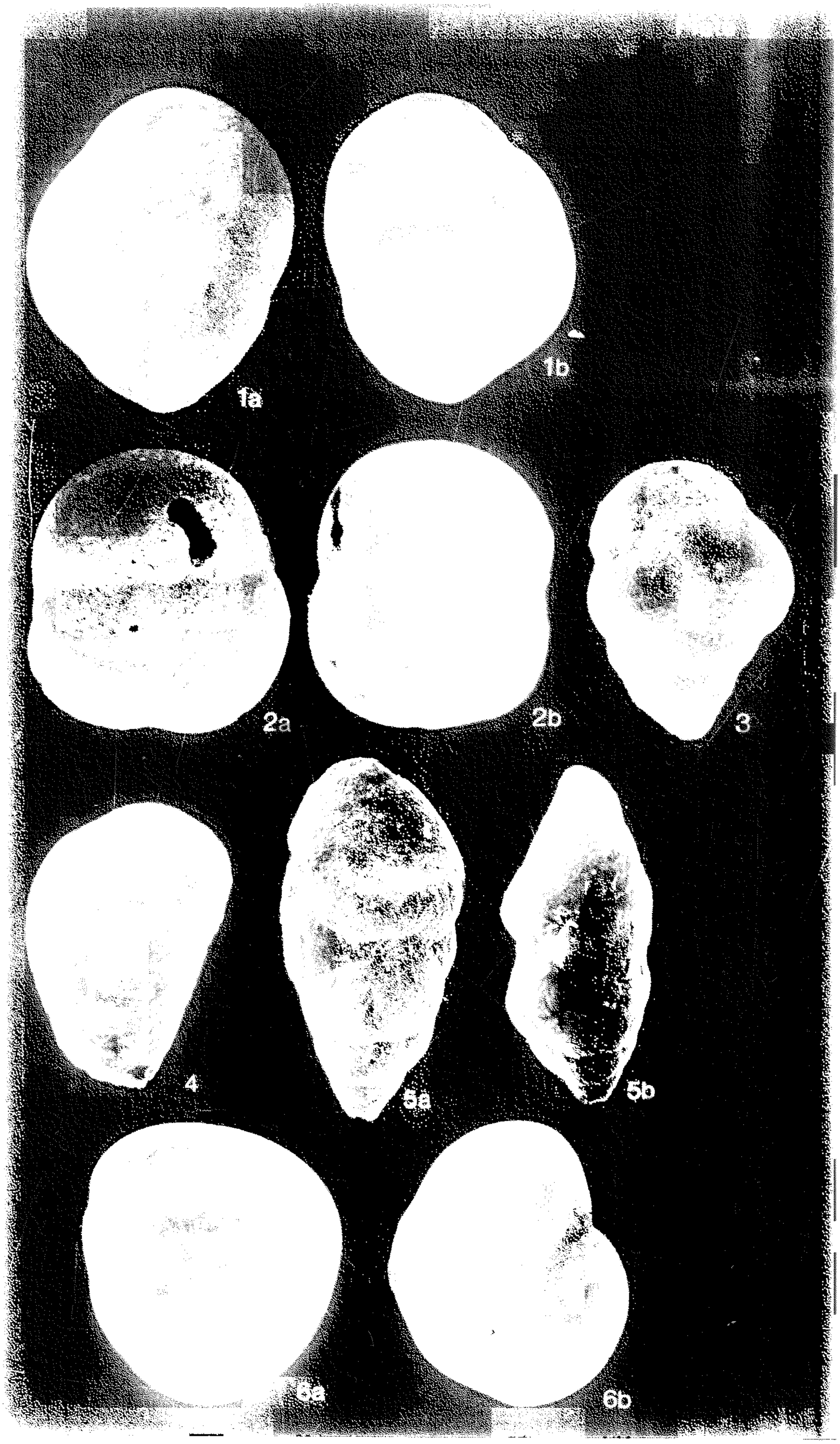

1a
1b
2a
2b
3
4
5a
5b
6a
6b

Plate 4

1. Ataxophragmium rimosum (Marsson), NS/030, 49/20-2, 3,020'

    (a) apertural view x73

    (b) side view x73

2. Ataxophragmium variabile (d'Orbigny), NS/028, 49/19-1, 1,740'

    (a) apertural view x38

    (b) side view x38

3. Orbignyna ovata von Hagenow, NS/058, 49/20-2, 3,020'

    (a) side view x38

    (b) apertural view x38

4. Orbignyna sherlocki Barnard, NS/047, 49/20-2, 3,200'

    (a) side view x46

    (b) apertural view x46

5. Volvoshinovella aequisgranensis (Beissel), NS/026, 44/2-1, 3,120'

    (a) side view x25

    (b) apertural view x25

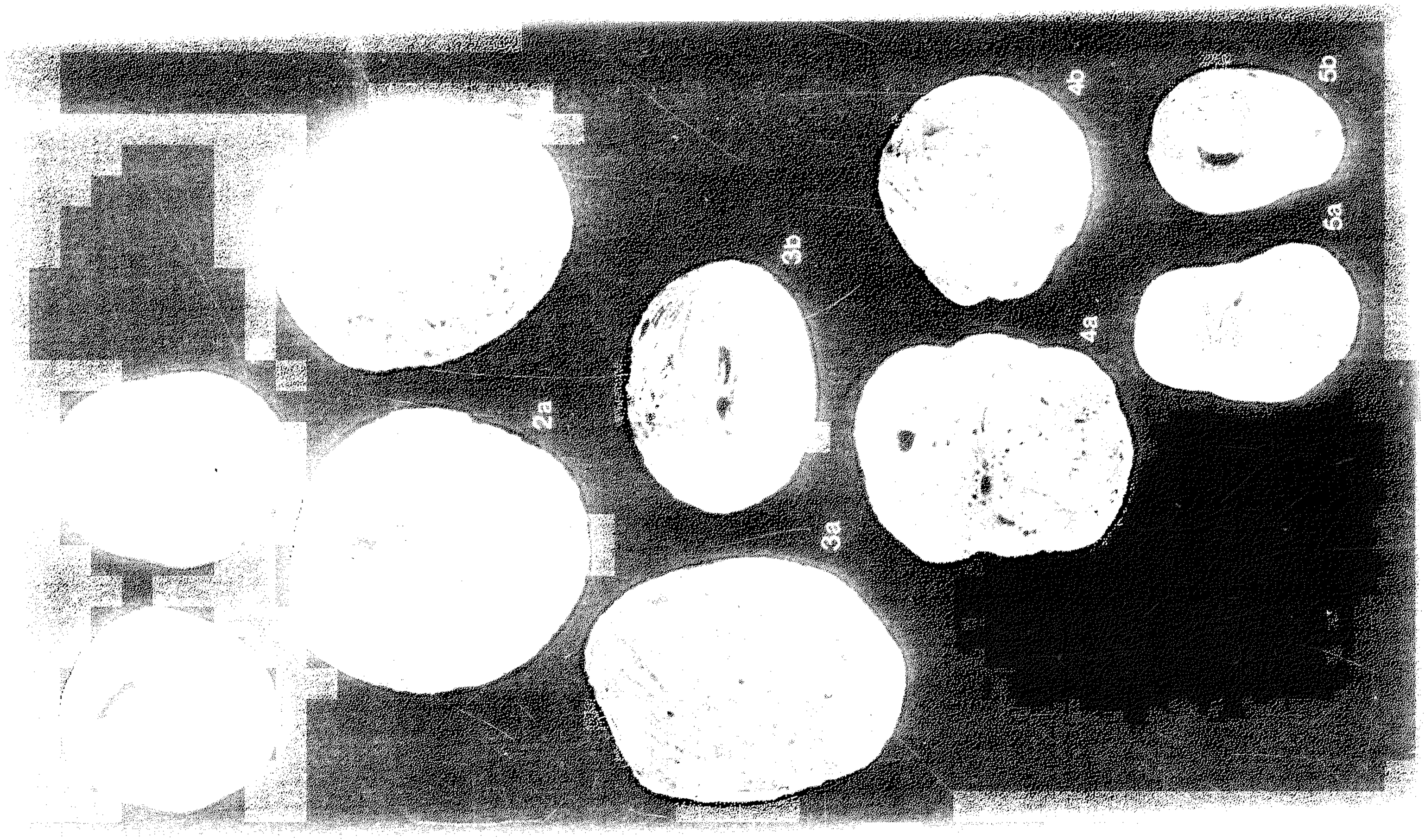

2a
3a
4a
5a
6a
7a
8a

Plate 5

1. Neoflabellina baudouinina (d'Orbigny), NS/082, 44/2-1, 4,610', side view, x84

2. Neoflabellina deltoidea (Wedekind) NS/025, 49/19-1, 2,450', side view, x80

3. Neoflabellina praerugosa Hiltermann, NS/024, 49/19-1, 2,450', side view, x80

4. Neoflabellina reticulata (Reuss), NS/029, 49/19-1, 1,680', side view, x73

5. Neoflabellina rugosa (d'Orbigny), NS/094, 44/2-1, 3,510', side view, x44

6. Vaginulinopsis scalariformis Porthault, NS/075, 49/19-1, 2,510', side view, x67

7. Praebulimina carseyae (Plummer), NS/014, 49/20-2, 3,350'
   (a) apertural view x64
   (b) side view x73

8. Praebulimina laevis (Beissel, NS/023, 49/19-1, 2,480'
   (a) apertural view x180
   (b) side view x180

9. Praebulimina obtusa (d'Orbigny), NS/110, 44/2-1, 3,870', apertural view, (broken specimen), x66

10. Praebulimina parva (Franke), NS/060, 49/19-1, 2,390', apertural view, (broken specimen), x160

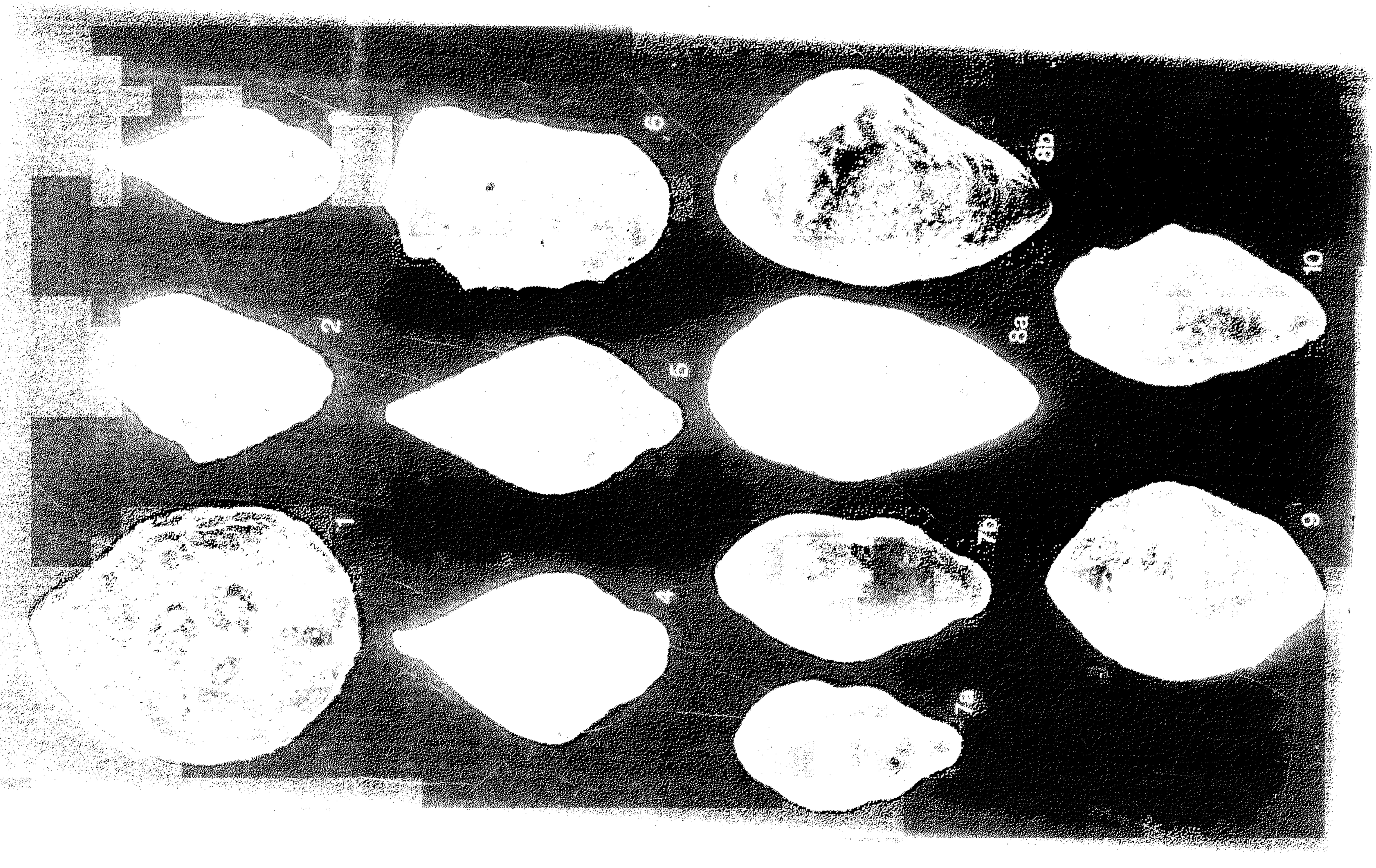
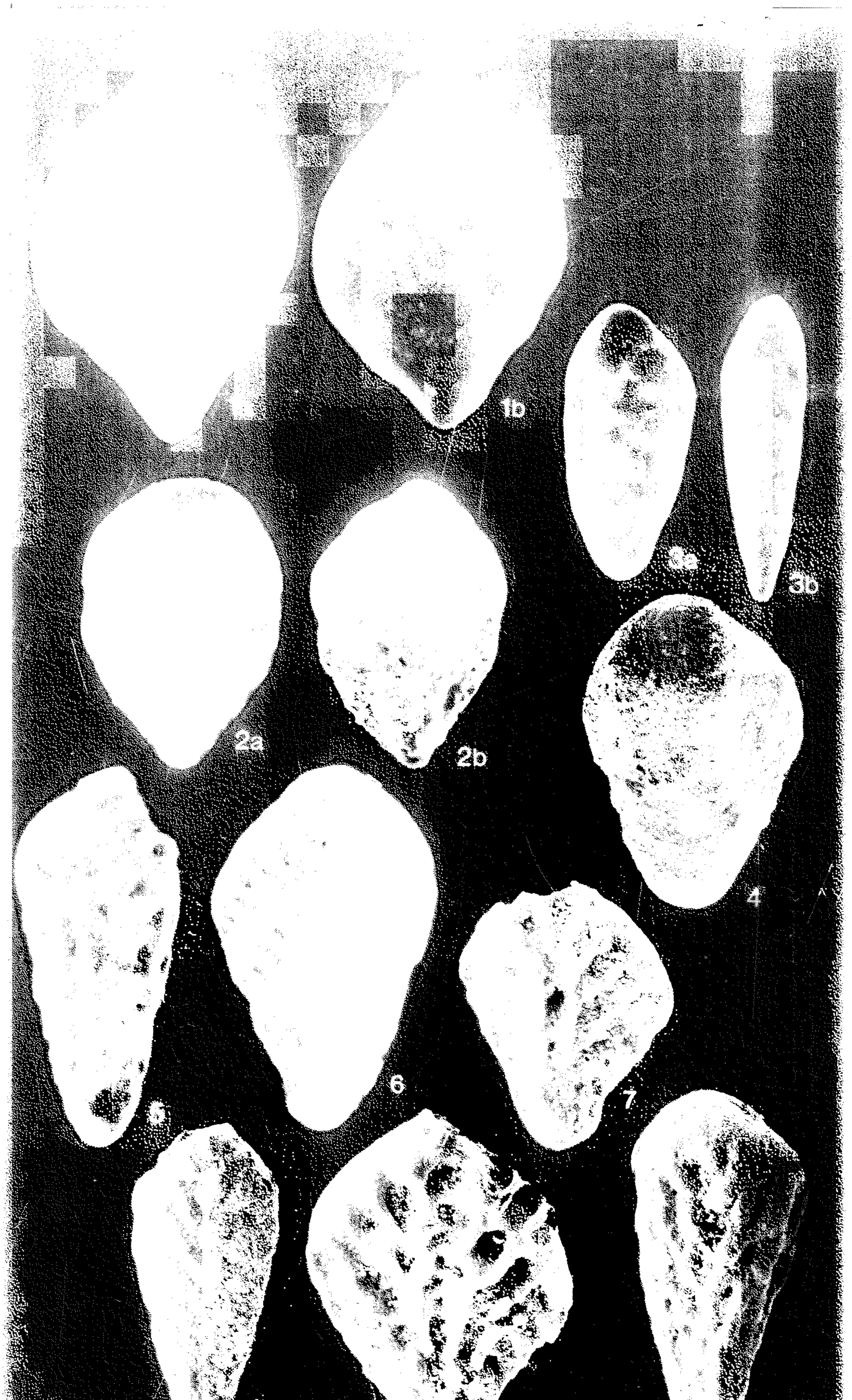


Plate 6

1. Praebulimina reussi (Morrow), NS/021, 49/19-1, 2,150'
   (a) apertural view x173
   (b) side view x173
2. Pyramidina trigonia (Chapman), NS/113, 49/19-1, 1,960'
   (a) apertural view x160
   (b) side view x160
3. Bolivina incrassata Reuss,
   (a) megalospheric form, NS/016, 44/2-1, 3,180',
   side view, x52
   (b) microspheric form, NS/015, 44/2-1, 3,180',
   side view x60
4. Bolivinoides australis Edgell., NS/091, 49/20-2, 3,500', side view, x167
5. Bolivinoides culverensis Barr, NS/038, 49/19-1, 2,000', side view, x120
6. Bolivinoides decoratus (Jones), NS/062, 49/20-2, 3,350', side view, x93
7. Bolivinoides draco (Marsson), (transitional from Bolivinoides miliaris), NS/087, 44/2-1, 2,970', side view, x120
8. Bolivinoides laevigatus Marie, NS/088, 44/2-1, 3,480', side view, x120
9. Bolivinoides miliaris Hiltermann & Koch, (transitional to Bolivinoides draco), NS/090, 44/2-1, 3,240', side view x120
10. Bolivinoides strigillatus (Chapman), NS/089, 49/19-1, 2,000', side view, x120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1b
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10

Plate 7

1. Reussella kelleri Vasilenko, NS/126, 44/2-1, 4,360', side view, x153

2. Reussella szajnochae praecursor De Klasz & Knipscheer, transitional to Reussella szajnochae szajnochae), NS/117, 44/2-1, 4,360', side view, x160

3. Reussella szajnochae szajnochae (Grzybowski), (transitional from Reussella szajnochae praecursor), NS/116, 44/2-1, 3,210', side view, x153

4. Pseudouvigerina cristata (Marsson), NS/076, 49/19-1, 1,590'

   (a) apertural view x113

   (b) side view x107

5. Pseudouvigerina rugosa Brotzen, NS/114, 49/19-1, 1,970'

   (a) apertural view x140

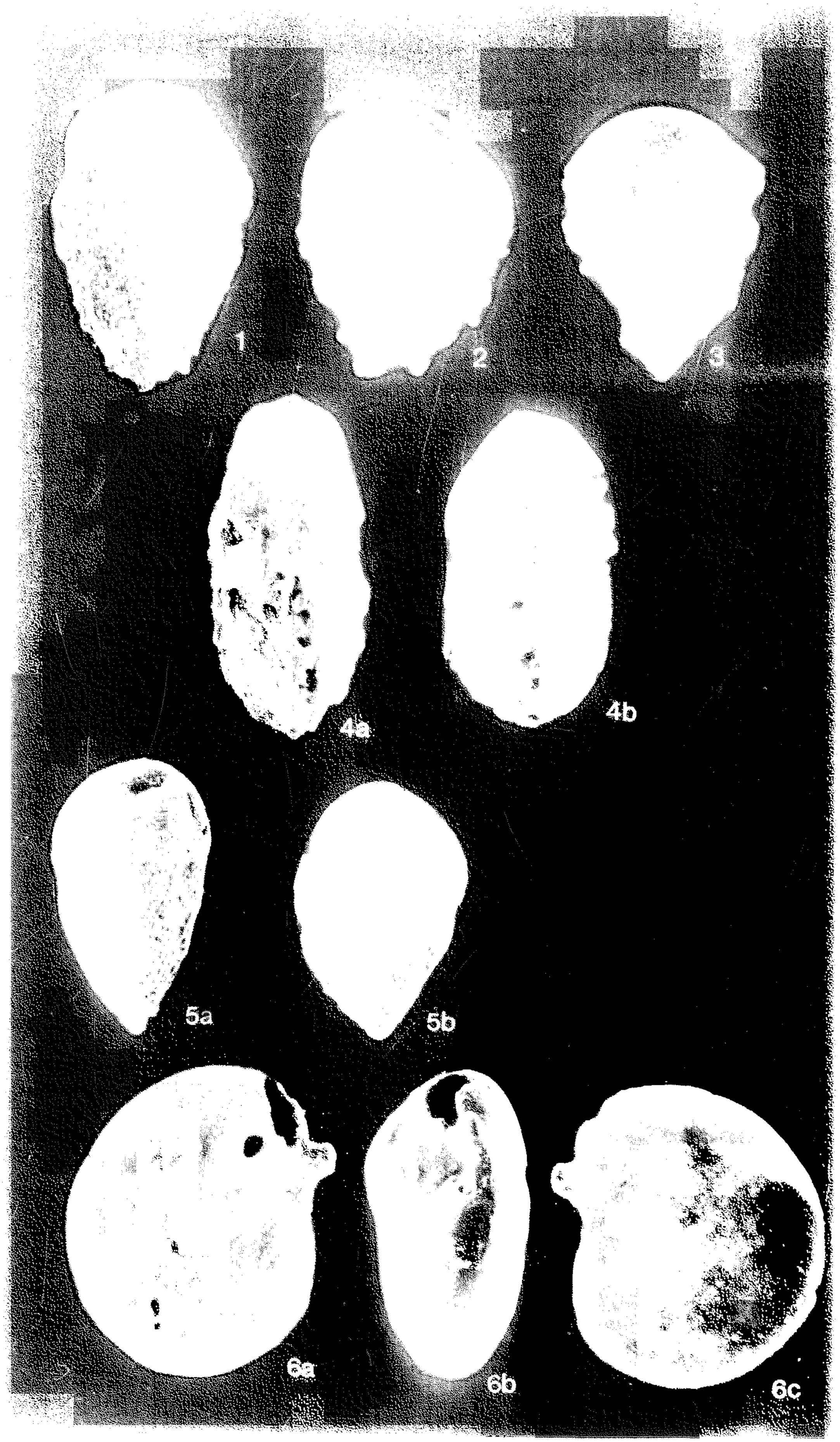
   (b) side view x140

6. Valvulineria lenticula (Reuss), NS/077, 49/19-1, 1,620'

   (a) umbilical view x200

   (b) side view x173

   (c) spiral view x200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6a
6b
6c

Plate 8

1. <u>Eponides beisseli</u> Schijfsma, NS/095, 44/2-1, 3,330'

   (a) umbilical view x100

   (b) side view x100

2. <u>Cibicides beaumontianus</u> (d'Orbigny), NS/007, 49/20-2, 3,200'

   (a) umbilical view x64

   (b) side view x50

   (c) spiral view x50

3. <u>Cibicides beaumontianus</u> (d'Orbigny) NS/069, 49/19-1, 1,590'

   (a) umbilical view x107

   (b)spiral view x105

1a
1b
2a
2b
3a
3b

Plate 9

1. Heterohelix complanata (Marie), NS/093, 44/2-1, 2,970'
   (a) side view x133
   (b) apertural view x133

2. Heterohelix globulosa (Ehrenberg), NS/050, 49/19-1, 2,000'
   (a) side view x140
   (b) apertural view x147

3. Heterohelix reussi (Cushman), NS/051, 49/19-1, 2,000'
   (a) side view x140
   (b) apertural view x140

4. Heterohelix striata (Ehrenberg), NS/092, 44/2-1, 2,970'
   (a) side view x240
   (b) apertural view x240

5. Globigerinelloides aspera (Ehrenberg), NS/071, 44/2-1, 3,240'
   (a) side view x173
   (b) apertural view x193

6. Globigerinelloides multispina (Lalicker), NS/107, 44/2-1, 3,300'
   (a) side view x160
   (b) apertural view x160

7. Globigerinelloides rowei (Barr), NS/121, 44/2-1, 4,520'
   (a) side view x140
   (b) apertural view x140

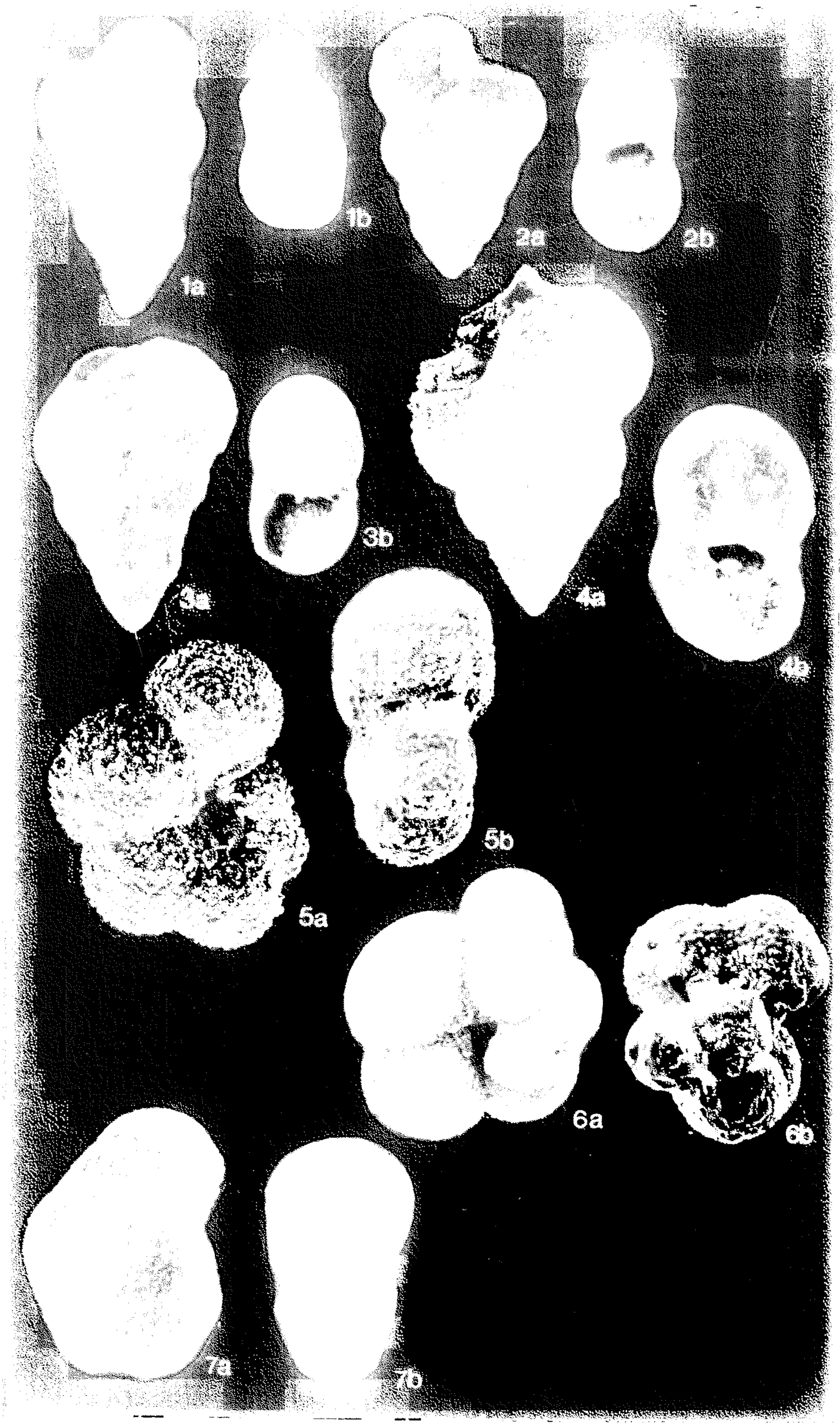

1a
1b
2a
2b
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b

Plate 10

1. Hedbergella brittonensis Loeblich & Tappan, NS/120, 49/19-1, 2,760'

(a) spiral view x140
(b) side view x140
(c) umbilical view x140

2. Hedbergella delrioensis (Carsey), NS/061, 49/20-2, 6,610'

(a) spiral view x160
(b) side view x153
(c) umbilical view x160

3. Hedbergella planispira (Tappan), NS/022, 49/20-2, 6,610'

(a) spiral view x193
(b) side view x187
(c) umbilical view x187

4. Whiteinella aprica (Loeblich & Tappan), NS/106, 44/2-1, 4,790'

(a) spiral view x140
(b) side view x140
(c) umbilical view x120

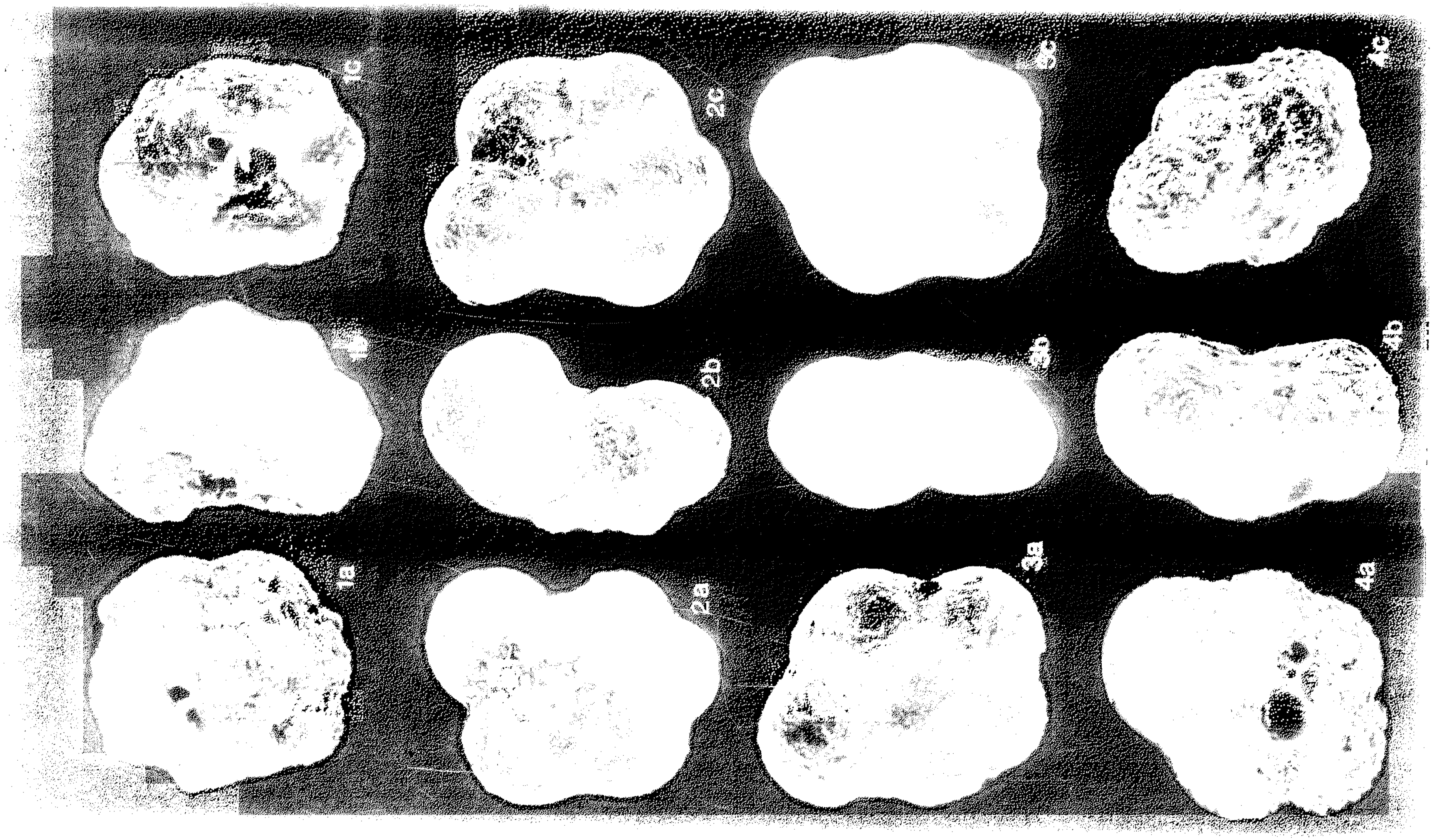

1a
2a
3a
4a
1b
2b
3b
4b

Plate 11

1. Whiteinella baltica Douglas & Rankin, NS/049, 49/19-1, 1,970'

   (a) spiral view x200

   (b) side view x200

   (c) umbilical view x200

2. Dicarinella algeriana (Caron), NS/096, 44/2-1, 4,910'

   (a) spiral view x107

   (b) side view x87

   (c) umbilical view x107

3. Dicarinella canaliculata (Reuss), NS/055, 49/19-1, 2,270'

   (a) spiral view x107

   (b) side view x100

   (c) umbilical view x100

4. Dicarinella concavata (Brotzen), NS/098, 44/2-1, 4,550'

   (a) spiral view x113

   (b) side view x113

   (c) umbilical view x113

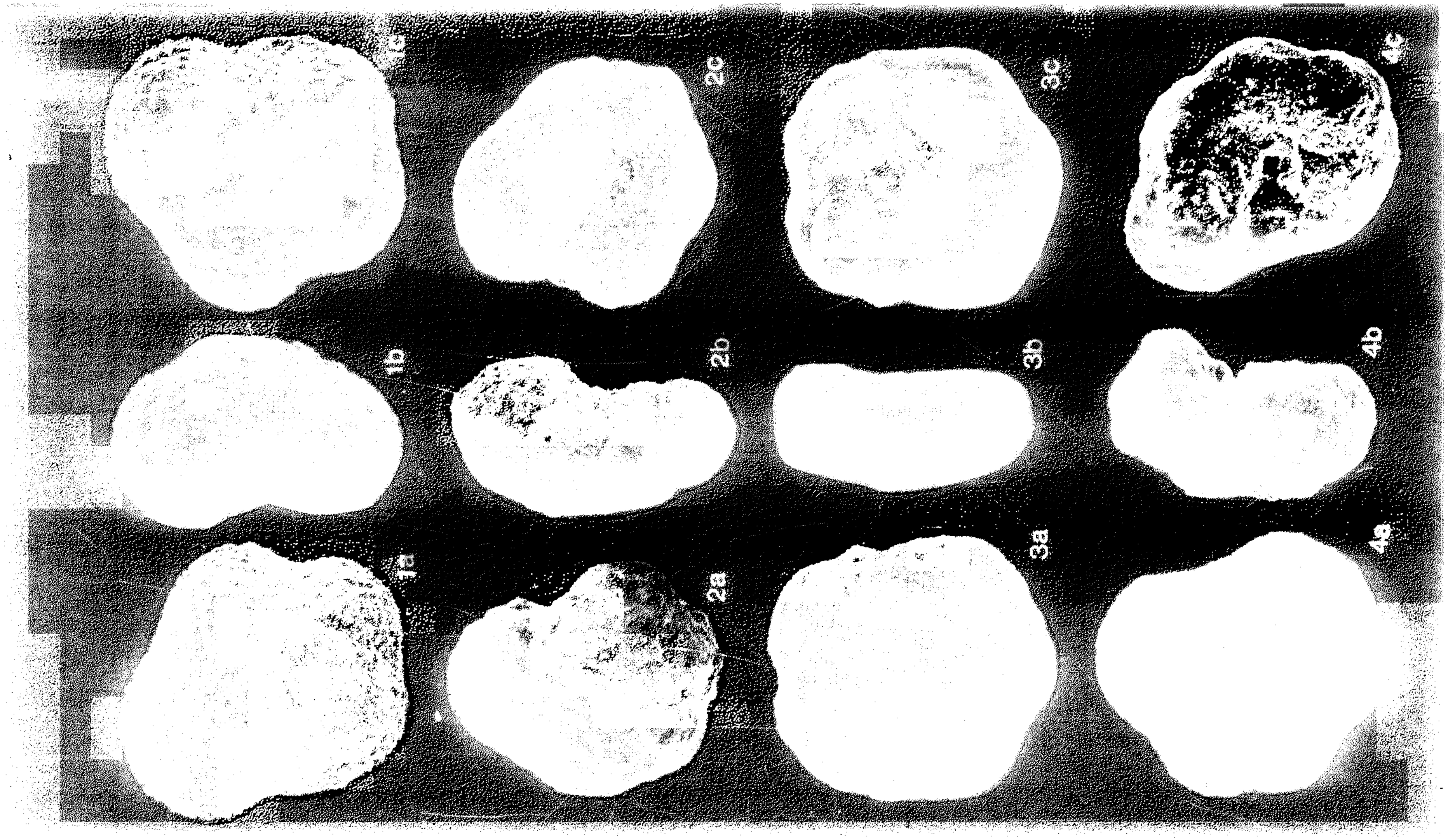

1a
2a
3a
4a
1b
2b
3b
4b
1c
2c
3c
4c

Plate 12

1. Dicarinella hagni (Scheibnerová), NS/097, 44/2-1, 5,000'

(a) spiral view x80

(b) side view x113

(c) umbilical view x80

2. Praeglobotruncana delrioensis (Plummer), NS/074, 49/20-2, 6,610'

(a) spiral view x200

(b) side view x200

(c) umbilical view x200

3. Praeglobotruncana helvetica (Bolli), NS/122, 49/19-1, 2,800'

(a) spiral view x160

(b) side view x160

(c) umbilical view x160

4. Praeglobotruncana stephani (Gandolfi), NS/043, 49/19-1, 2,910'

(a) spiral view x147

(b) side view x147

(c) umbilical view x147

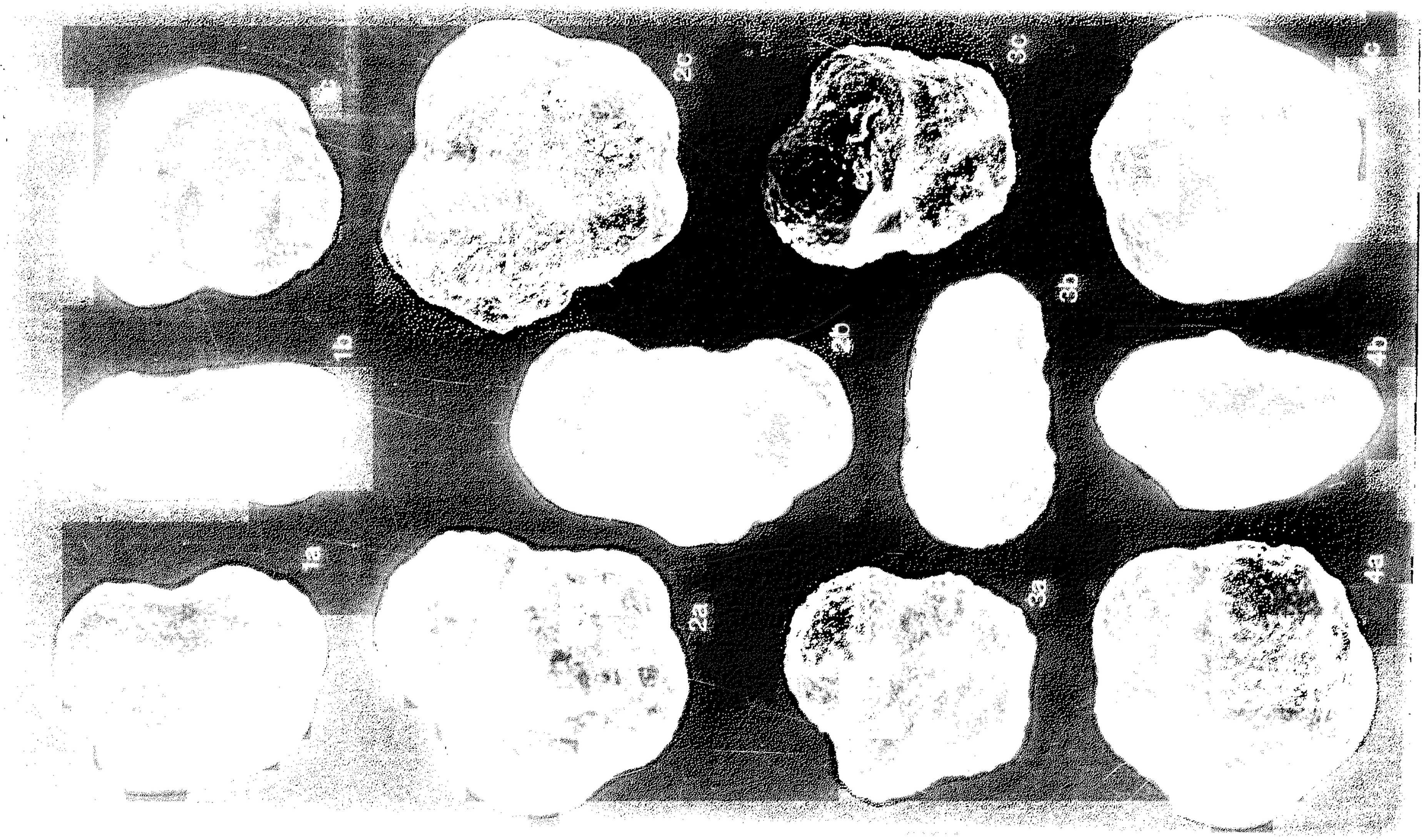


Plate 13

1. Globotruncana arca Cushman, NS/065, 44/2-1, 3,210'

   (a) spiral view x127

   (b) side view x113

   (c) umbilical view x120

2. Globotruncana bulloides Vogler, NS/052, 49/19-1, 2,060'

   (a) spiral view x120

   (b) side view x120

   (c) umbilical view x120

3. Globotruncana contusa (Cushman), NS/064, 44/2-1, 3,210'

   (a) spiral view x73

   (b) side view x69

   (c) umbilical view x73

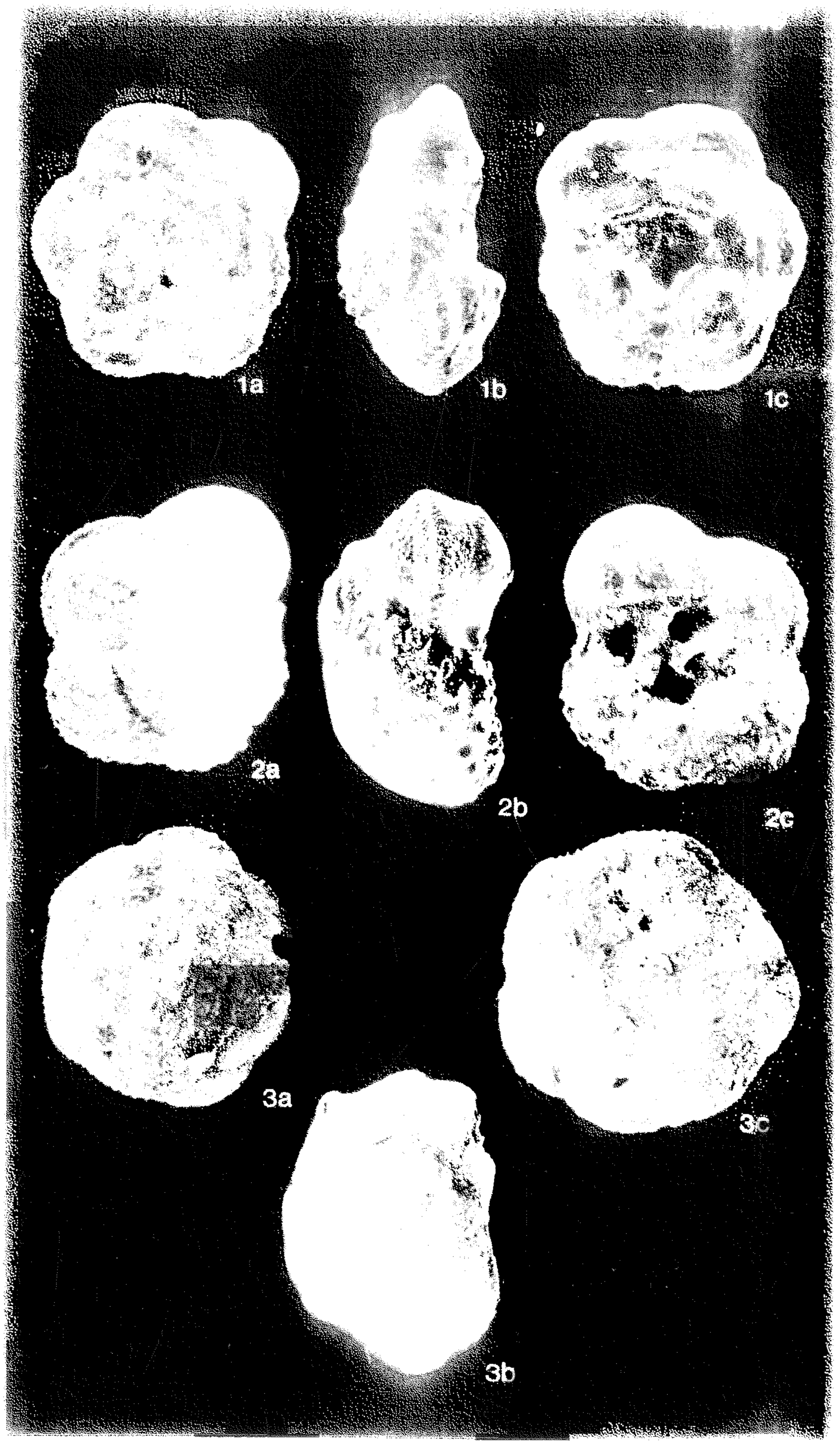

1a
1b
1c
2a
2b
2c
3a
3b
3c

Plate 14

1. Globotruncana linneiana (d'Orbigny), NS/068, 44/2-1, 3,360'

   (a) spiral view x140
   (b) side view x120
   (c) umbilical view x120

2. Abathomaphalus intermedius (Bolli), NS/104, 44/2-1, 3,240'

   (a) spiral view x193
   (b) side view x187
   (c) umbilical view x187

3. Abathomaphalus mayaroensis (Bolli), NS/066, 44/2-1, 3,240'

   (a) spiral view x113
   (b) side view x120
   (c) umbilical view x100

4. Archaeoglobigerina cretacea (d'Orbigny), NS/039, 49/19-1, 2,000'

   (a) spiral view x120
   (b) side view x120
   (c) umbilical view x120

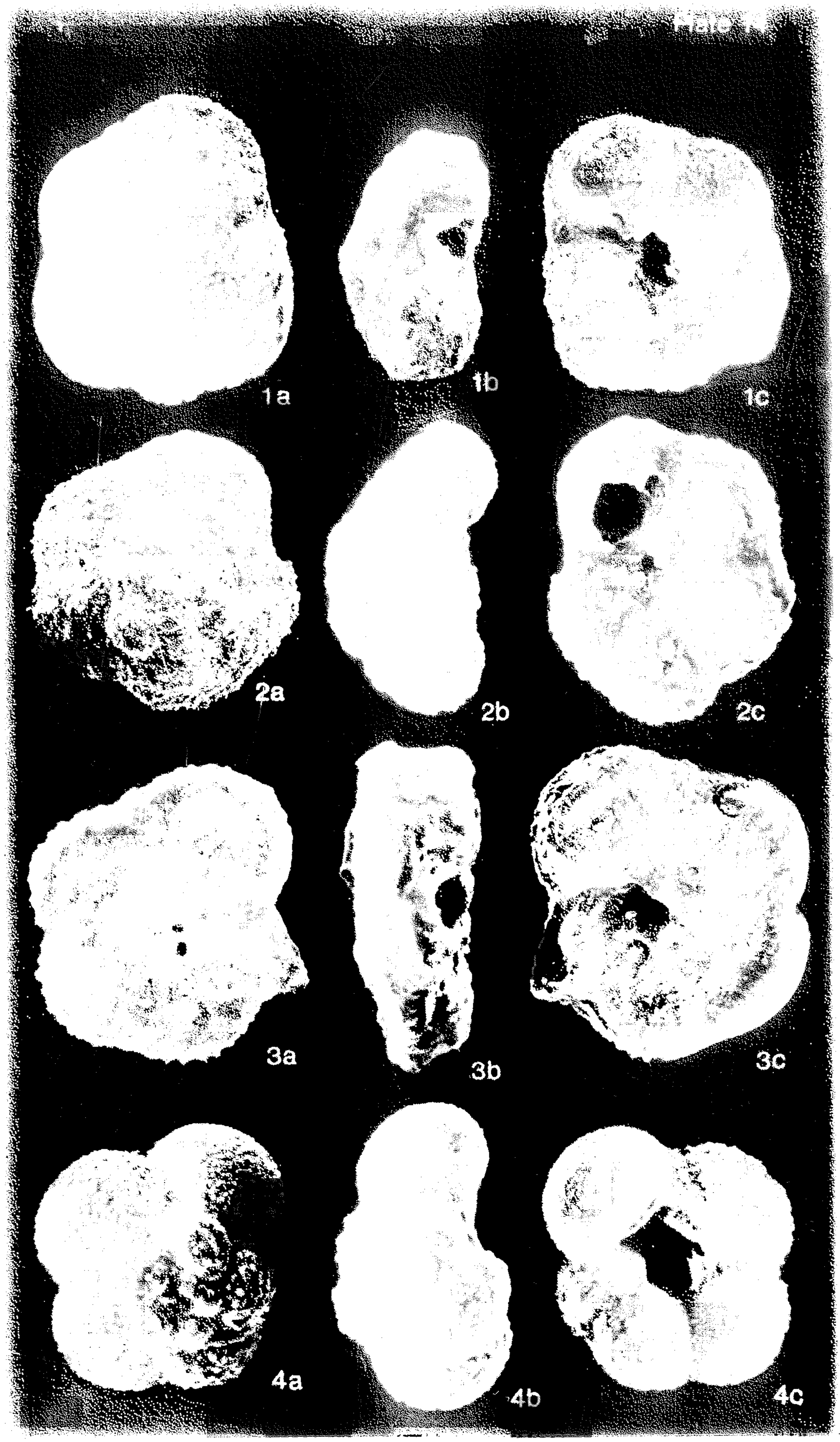

1a
1b
1c
2a
2b
2c
3a
3b
3c
4a
4b
4c

Plate 15

1. Globotruncanella havanensis (Voorwijk), NS/063, 44/2-1, 3,210'

   (a) spiral view x180

   (b) side view x140

   (c) umbilical view x167

2. Marginotruncana marginata (Reuss), NS/053, 49/19-1, 2,300'

   (a) spiral view x87

   (b) side view x87

   (c) umbilical view x87

3. Marginotruncana pseudolinneiana Pessagno, NS/054, 49/19-1, 2,350'

   (a) spiral view x120

   (b) side view x120

   (c) umbilical view x120

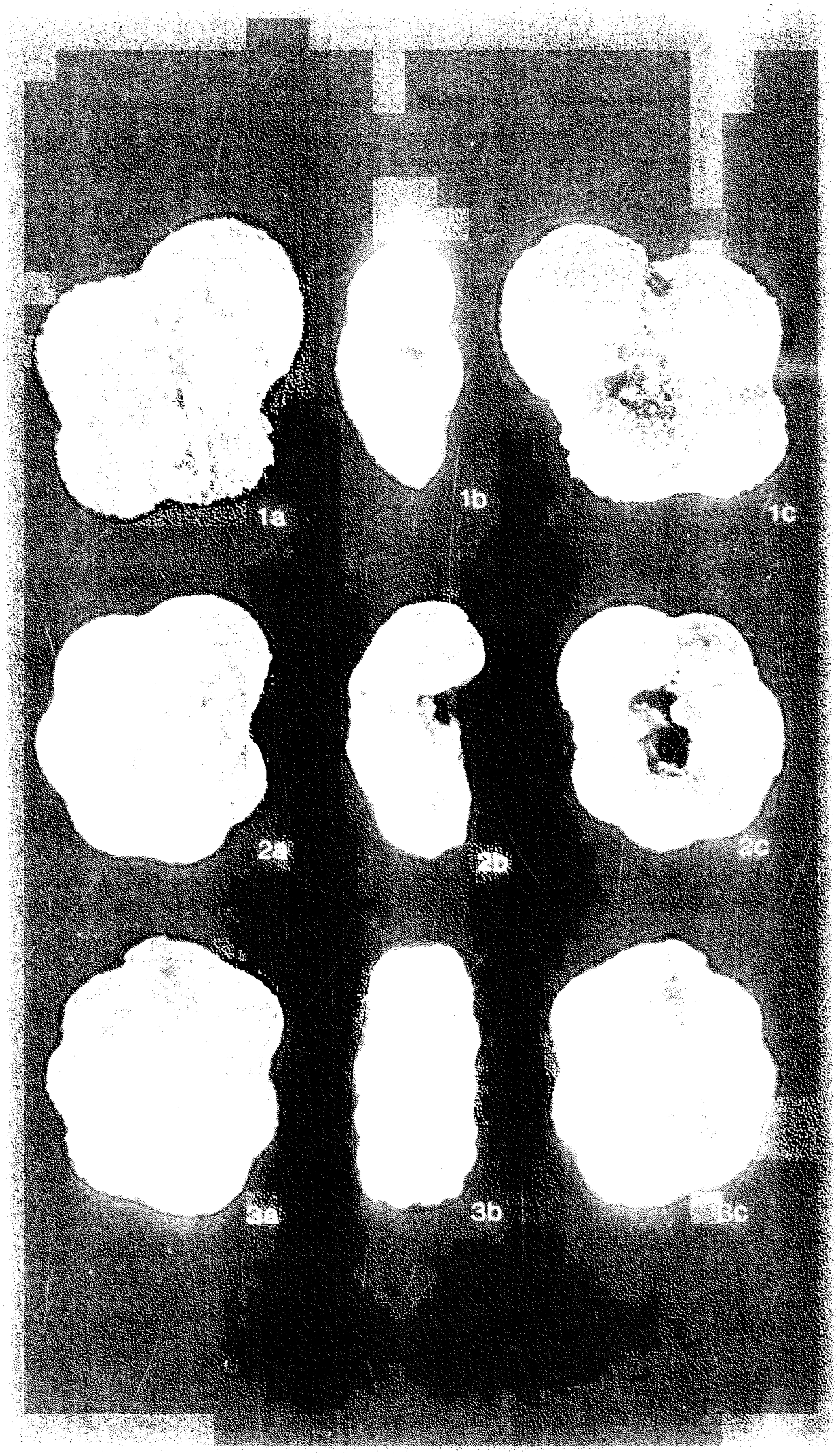

1a
1b
1c
2a
2b
2c
3a
3b
3c

Plate 16

1. Rugoglobigerina milamensis Smith & Pessagno, NS/042, 49/19-1, 1,910'

(a) spiral view x120
(b) side view x120
(c) umbilical view x120

2. Rugoglobigerina rotundata Brönnimann, NS/102, 44/2-1, 3,090'

(a) spiral view x140
(b) side view x140
(c) umbilical view x140

3. Rugoglobigerina rugosa (Plummer) NS/034, 44/2-1, 3,240'

(a) spiral view x200
(b) side view x200
(c) umbilical view x200

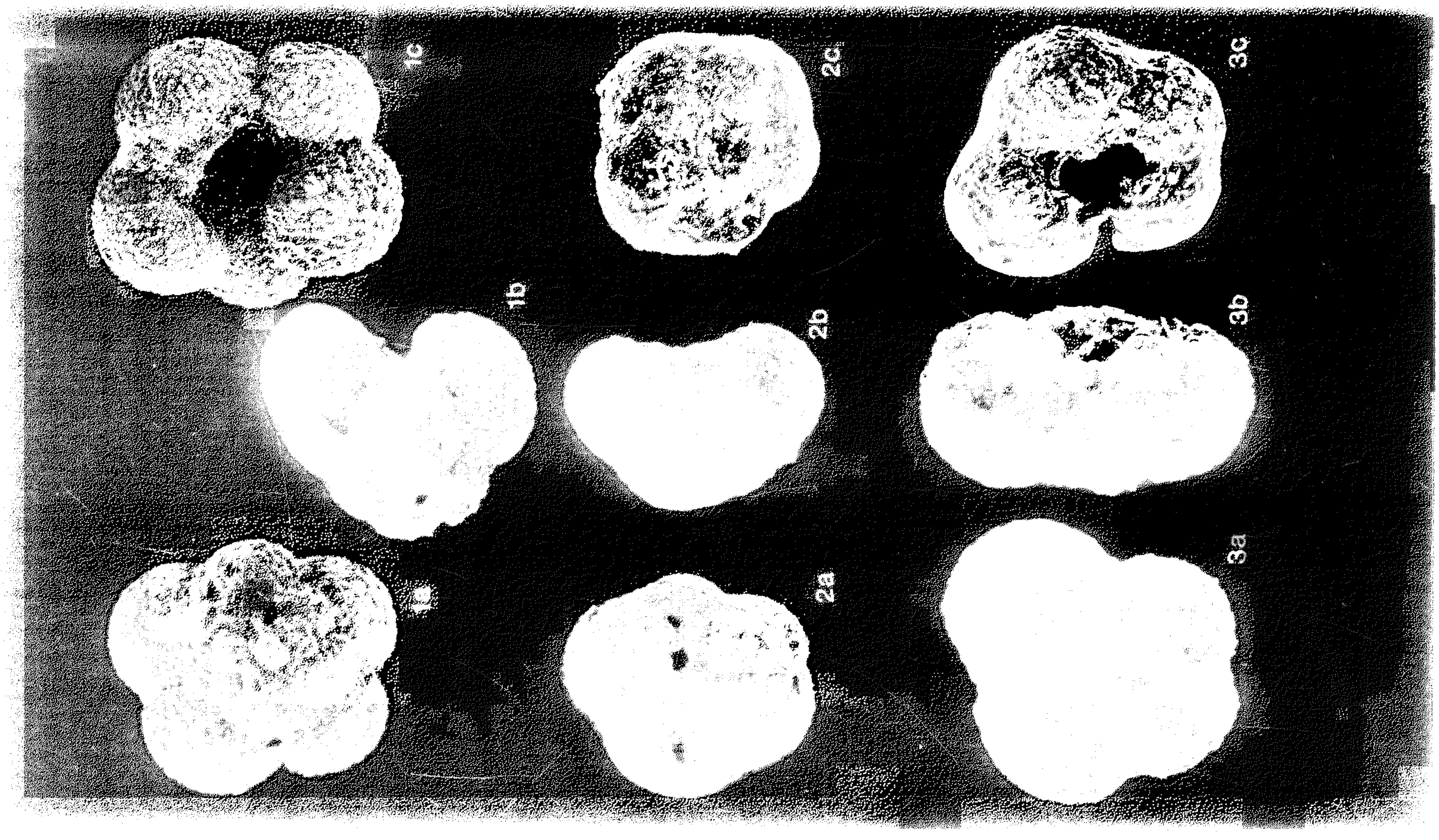

1c
2c
3c
1b
2b
3b
1a
2a
3a

Plate 17

1. Pullenia quaternaria (Reuss), NS/010, 49/19-1, 1,620'

   (a) umbilical view x220
   (b) apertural view x213

2. Pullenia reussi Cushman & Todd, NS/067, 44/2-1, 3,060'

   (a) apertural view x153
   (b) umbilical view x160

3. Osangularia cordieriana (d'Orbigny), NS/070, 44/2-1, 3,390'

   (a) umbilical view x100
   (b) side view x100
   (c) spiral view x100

4. Osangularia navarroana (Cushman), NS/072, 44/2-1, 3,330'

   (a) umbilical view x100
   (b) side view x100
   (c) spiral view x100

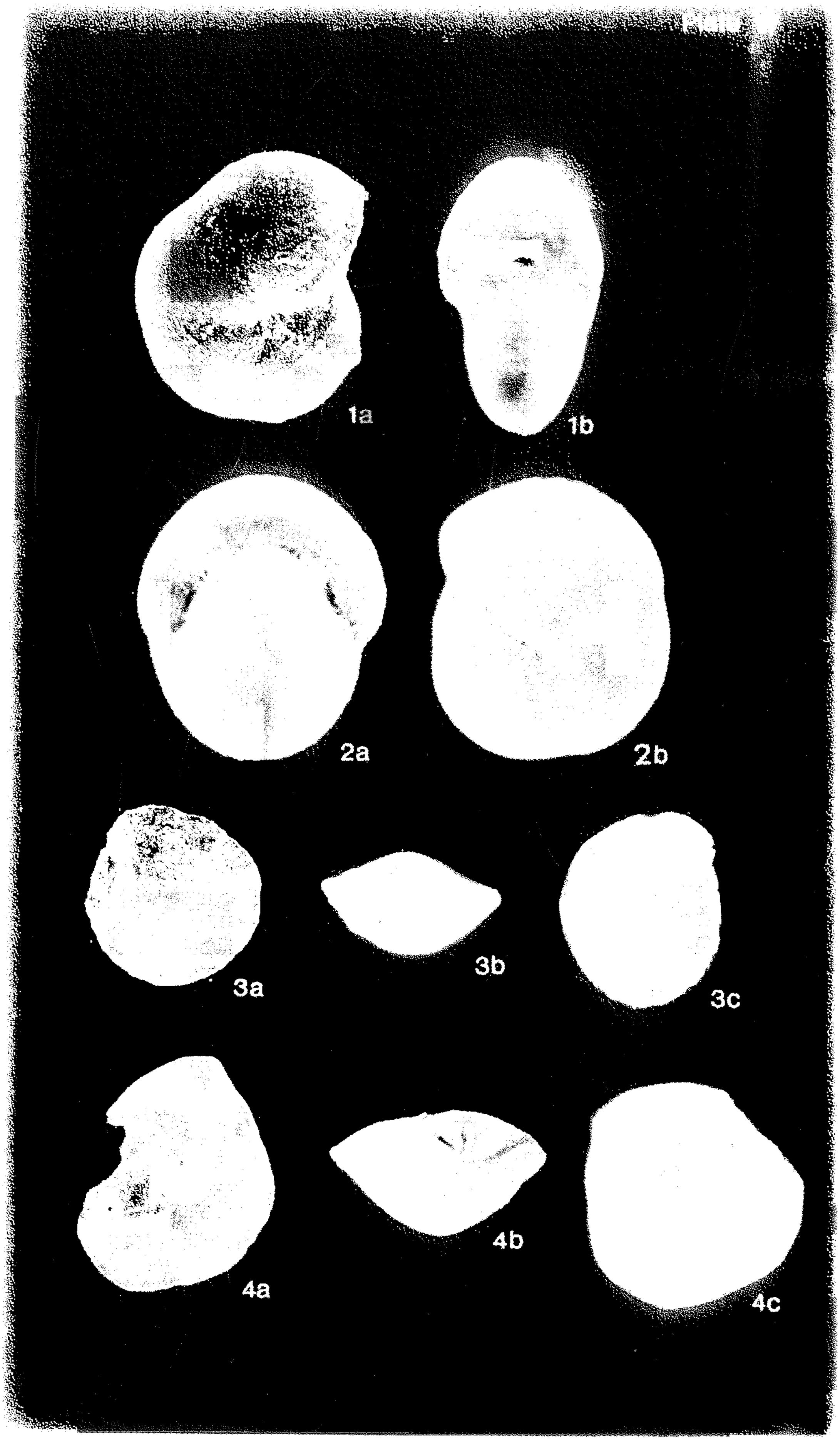

1a
1b
2a
2b
3a
3b
3c
4a
4b
4c

Plate 18

1. Osangularia whitei (Brotzen), NS/057, 49/19-1, 2,480'

   (a) umbilical view x100

   (b) side view x100

   (c) spiral view x100

2. Globorotalites conicus (Carsey), NS/123, 44/2-1, 3,930'

   (a) umbilical view x107

   (b) side view x107

3. Globorotalites hiltermanni Kaever, NS/078, 49/20-2, 3,650'

   (a) umbilical view x93

   (b) side view x93

4. Globorotalites micheliniana (d'Orbigny)

   (a) NS/012, 49/19-1, 1,970', umbilical view x153

   (b) NS/011, 49/19-1, 1,970', spiral view x153

   (c) NS/011, 49/19-1, 1,970', side view x160

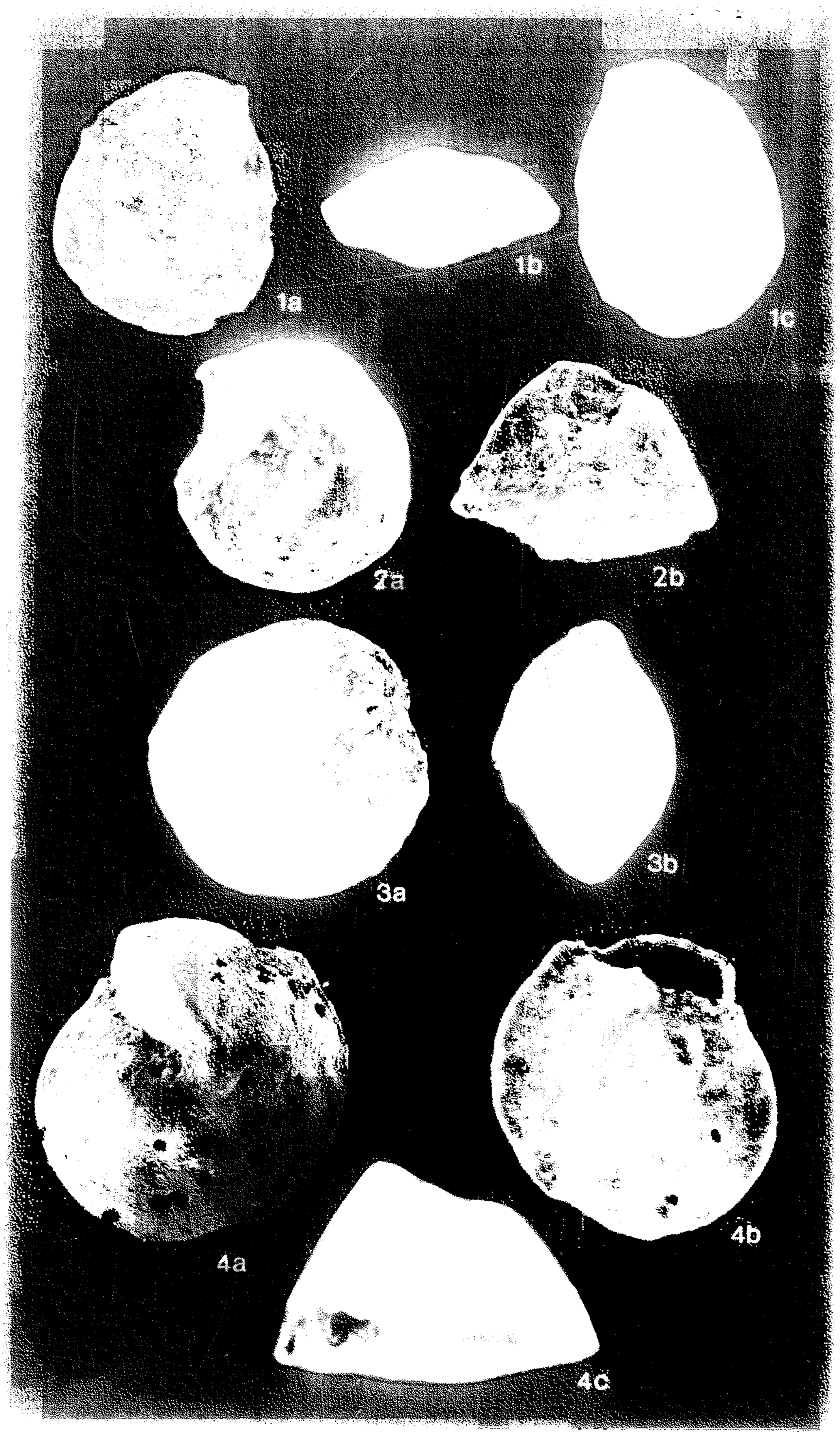

1a
1b
1c
2a
2b
3a
3b
4a
4b
4c

Plate 19

1. Gyroidinoides nitida (Reuss)

   (a) NS/001, 44/2-1, 3,060', umbilical view x147
   (b) NS/002, 44/2-1, 3,060', spiral view x147
   (c) NS/001, 44/2-1, 3,060', side view x120

2. Angulogavelinella bettenstaedti Hofker, NS/105, 44/2-1, 3,660'

   (a) umbilical view x140
   (b) side view x140
   (c) spiral view x140

3. Cibicidoides (?) voltziana (d'Orbigny)

   (a) NS/019, 49/20-2, 3,020', spiral view x50
   (b) NS/019, 49/20-2, 3,020', umbilical view x50
   (c) NS/031, 49/20-2, 3,020', side view x88

4. Gavelinella baltica Brotzen, NS/100, 49/20-2, 6,610'

   (a) umbilical view x93
   (b) side view x93
   (c) spiral view x93

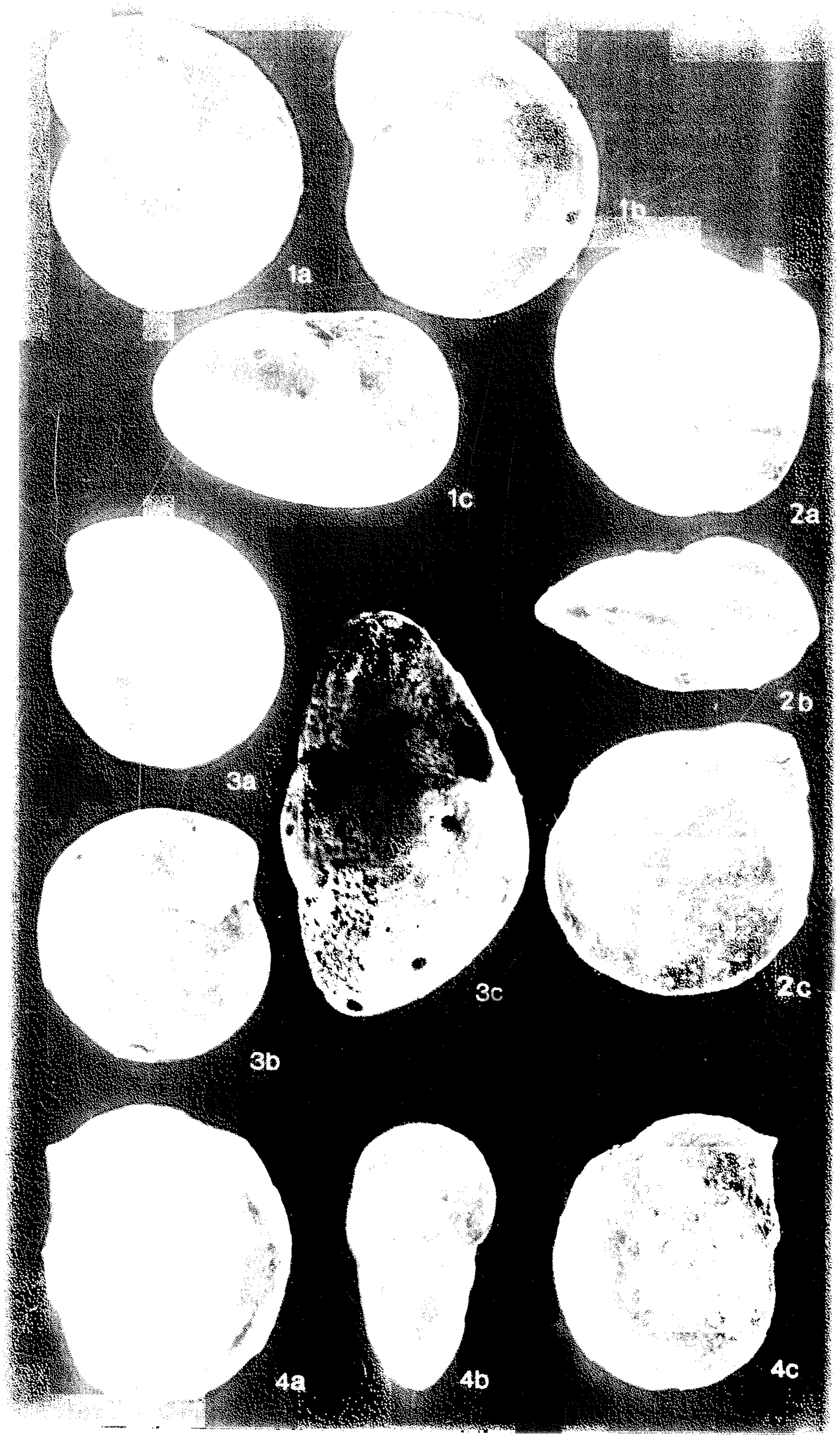

1a
1b
1c
2a
2b
2c
3a
3b
3c
4a
4b
4c

Plate 20

1. Gavelinella bembix (Marsson), NS/108, 44/2-1, 2,970'

(a) spiral view x133

(b) side view x133

(c) umbilical view x133

2. Gavelinella clementiana clementiana (d'Orbigny), NS/040, 49/19-1, 1,910'

(a) umbilical view x73

(b) side view x73

(c) spiral view x73

3. Gavelinella clementiana laevigata (Marie), NS/041, 49/19-1, 1,910'

(a) umbilical view x51

(b) side view x51

(c) spiral view x51

4. Gavelinella cristata (Goel), NS/119, 44/2-1, 4,110'

(a) umbilical view x80

(b) side view x80

(c) spiral view x80

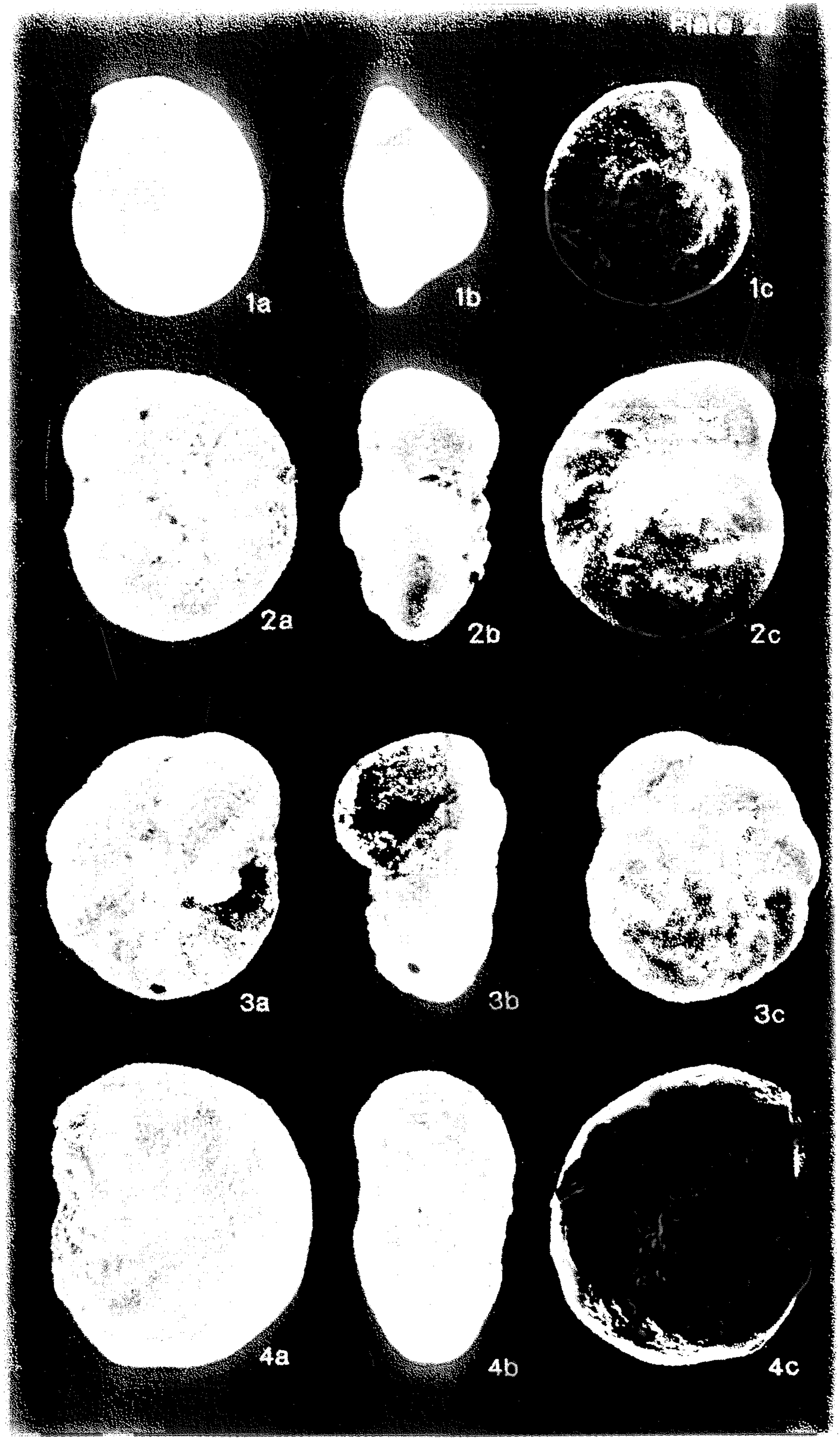

1a
1b
1c
2a
2b
2c
3a
3b
3c
4a
4b
4c

Plate 21

1. Gavelinella cenomanica (Brotzen), NS/009, 49/20-2, 6,610'

(a) umbilical view x133

(b) side view x133

(c) spiral view x133

2. Gavelinella gp. intermedia (Berthelin), NS/101, 49/20-2, 6,610'

(a) umbilical view x107

(b) side view x107

(c) spiral view x107

3. Gavelinella lorneiana (d'Orbigny), NS/112, 49/19-1, 1,970'

(a) umbilical view x93

(b) side view x100

(c) spiral view x100

4. Gavelinella monterelensis (Marie), NS/035, 49/20-2, 3,620'

(a) umbilical view x93

(b) side view x93

(c) spiral view x93

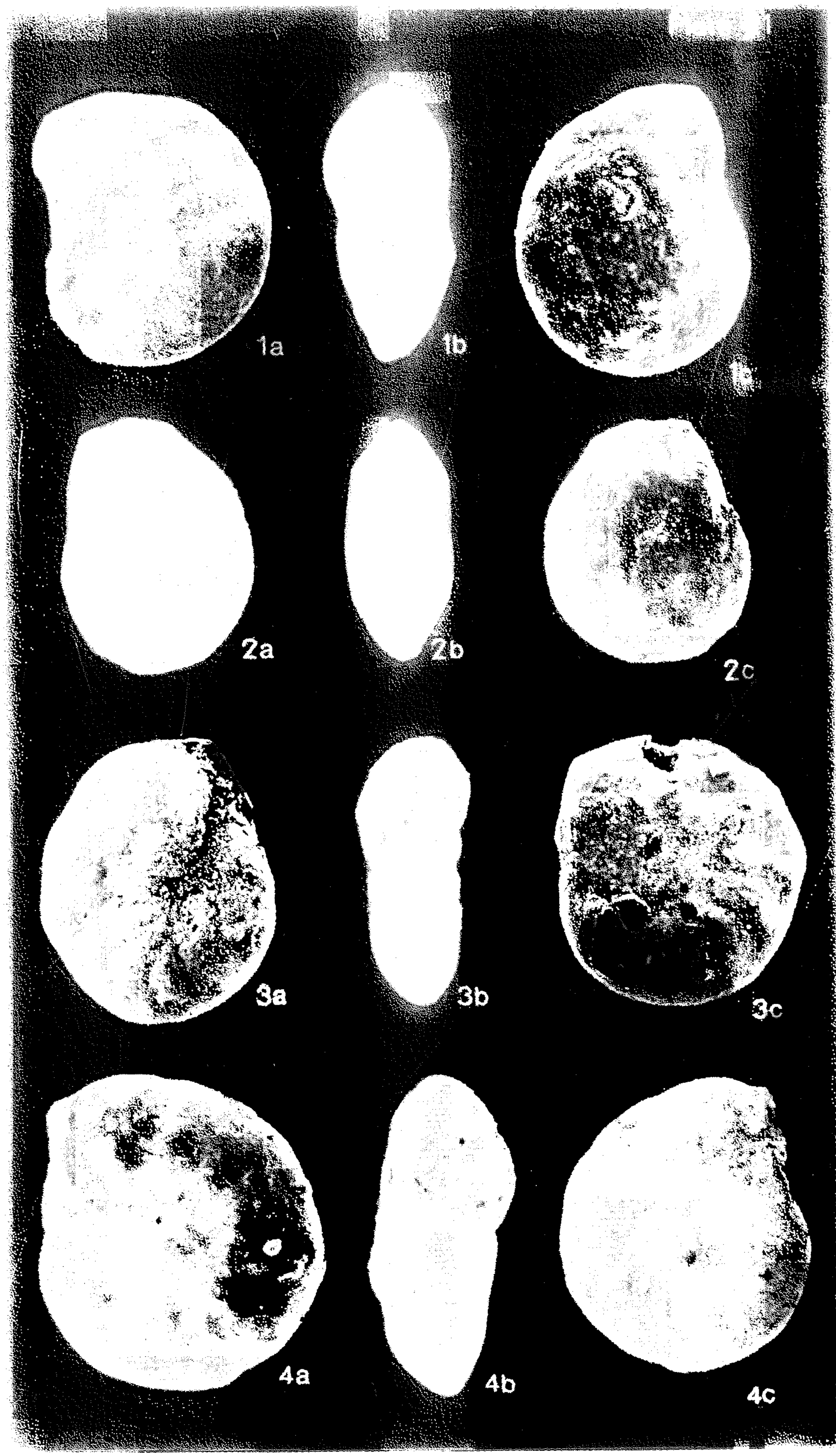

1a
1b
2a
2b
2c
3a
3b
3c
4a
4b
4c

Plate 22

1. Gavelinella pertusa (Marsson), NS/008, 49/19-1, 1,970'

   (a) umbilical view x160
   (b) side view x120
   (c) spiral view x120

2. Gavelinella stelligera (Marie), NS/044, 49/19-1, 2,240'

   (a) umbilical view x133
   (b) side view x133
   (c) spiral view x133

3. Gavelinella thalmanni (Brotzen), NS/109, 44/2-1, 4,020'

   (a) umbilical view x113
   (b) side view x113
   (c) spiral view x113

4. Gavelinella cf. tourainensis (Butt), NS/129, 44/2-1, 4,910'

   (a) umbilical view x140
   (b) side view x127
   (c) spiral view x127

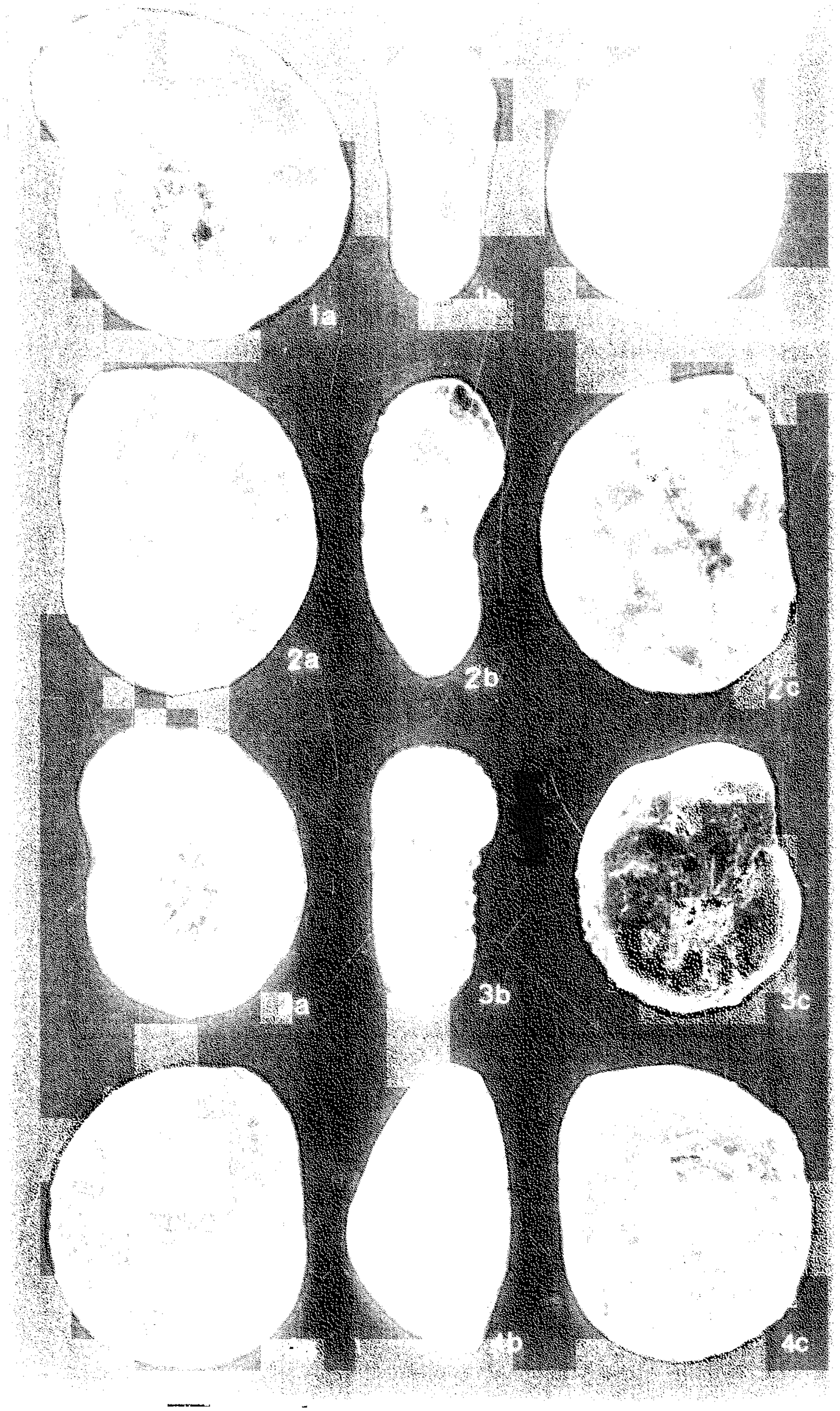

2a
2b
2c
3a
3b
3c
4b
4c

Plate 23

1. Gavelinella tourainensis (Butt), NS/125, 44/2-1, 4,580'

   (a) umbilical view x140
   (b) side view x140
   (c) spiral view x140

2. Gavelinella tumida Brotzen NS/124, 44/2-1, 4,580'

   (a) umbilical view x140
   (b) side view x120
   (c) spiral view x120

3. Gavelinella usakensis (Vasilenko), NS/118, 44/2-1, 3,990'

   (a) umbilical view x80
   (b) side view x80
   (c) spiral view x80

4. Lingulogavelinella globosa (Brotzen), NS/115, 44/2-1, 4,940'

   (a) umbilical view x140
   (b) side view x140
   (c) spiral view x140

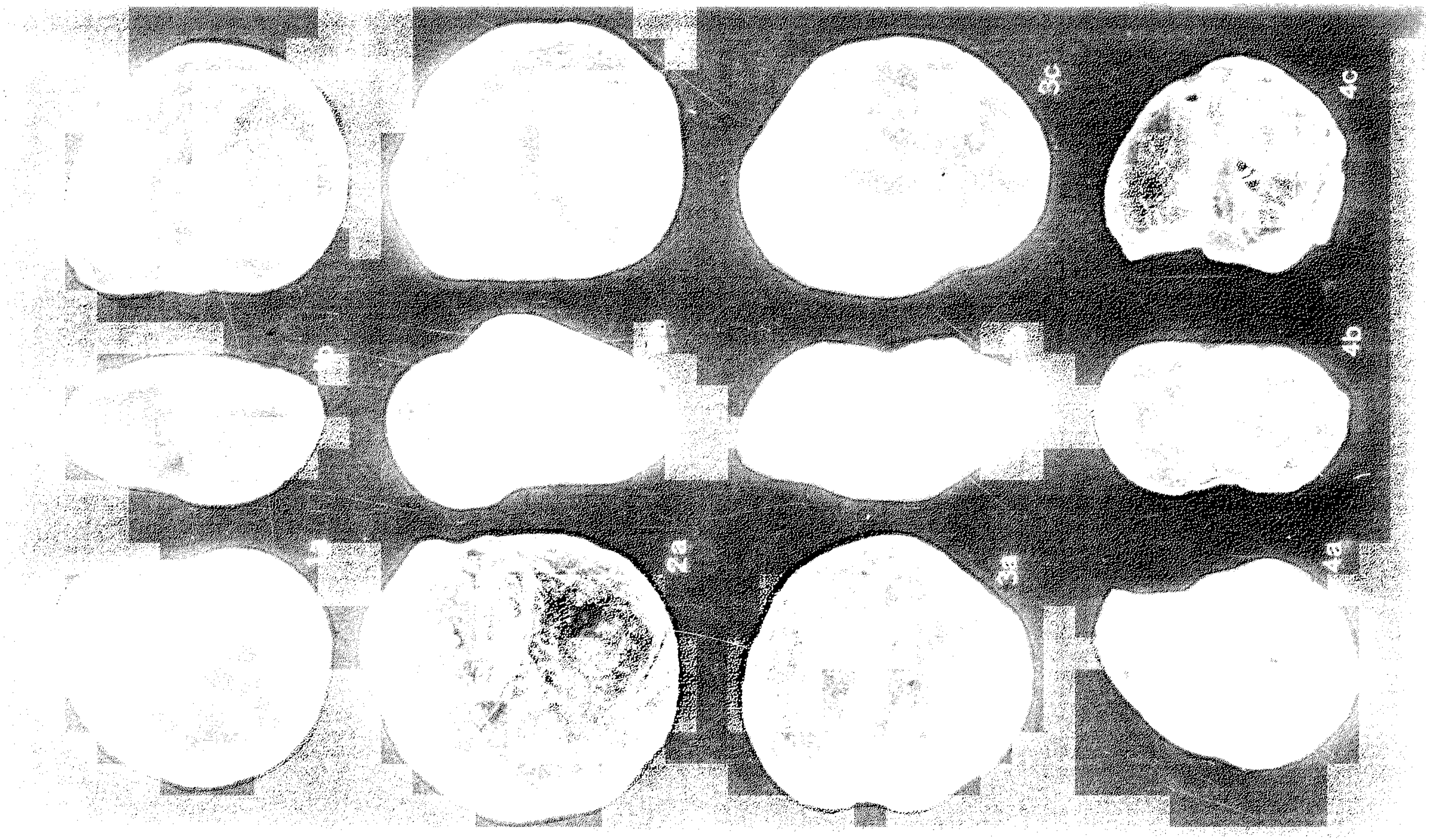


Plate 24

1. Lingulogavelinella sp. cf. L. vombensis (Brotzen), NS/073, 49/19-1, 2,640'

(a) umbilical view x120
(b) side view x120
(c) spiral view x120

2. Stensioeina exsculpta exsculpta (Reuss), NS/079, 49/19-1, 2,270'

(a) umbilical view x120
(b) side view x140
(c) spiral view x120

3. Stensioeina exsculpta gracilis Brotzen, NS/032, 49/19-1, 1,940'

(a) umbilical view x120
(b) side view x100
(c) spiral view x120

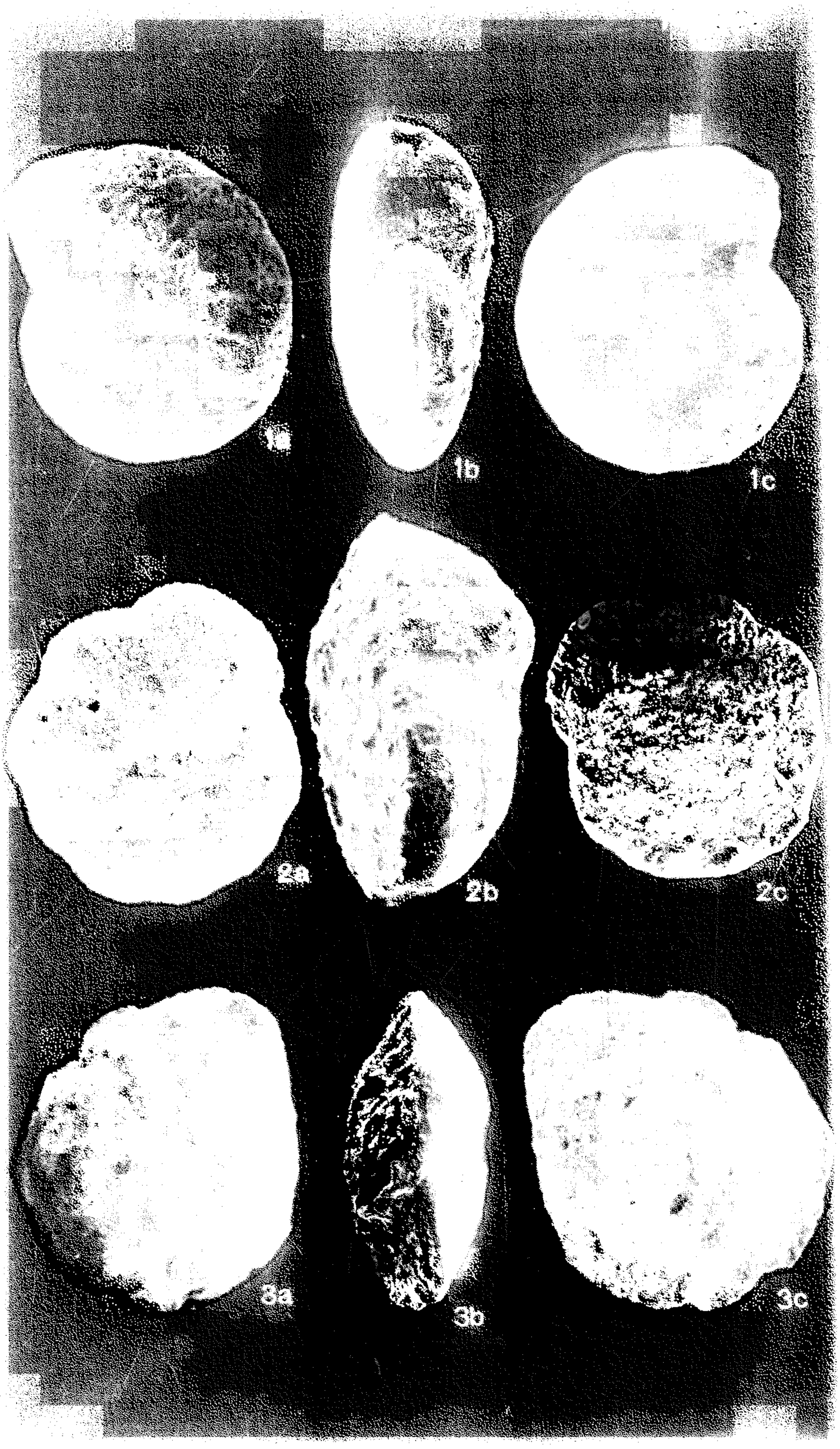

1a
1b
1c
2a
2b
2c
3a
3b
3c

Plate 25

1. Stensioeina granulata granulata (Olbertz), NS/127, 49/19-1, 2,510'

(a) umbilical view x147

(b) side view x153

(c) spiral view x147

2. Stensioeina granulata polonica Witwicka, NS/128, 44/2-1, 4,550'

(a) umbilical view x120

(b) side view x120

(c) spiral view x120

3. Stensioeina pommerana Brotzen, NS/068, 44/2-1, 3,390'

(a) umbilical view x113

(b) side view x113

(c) spiral view x100

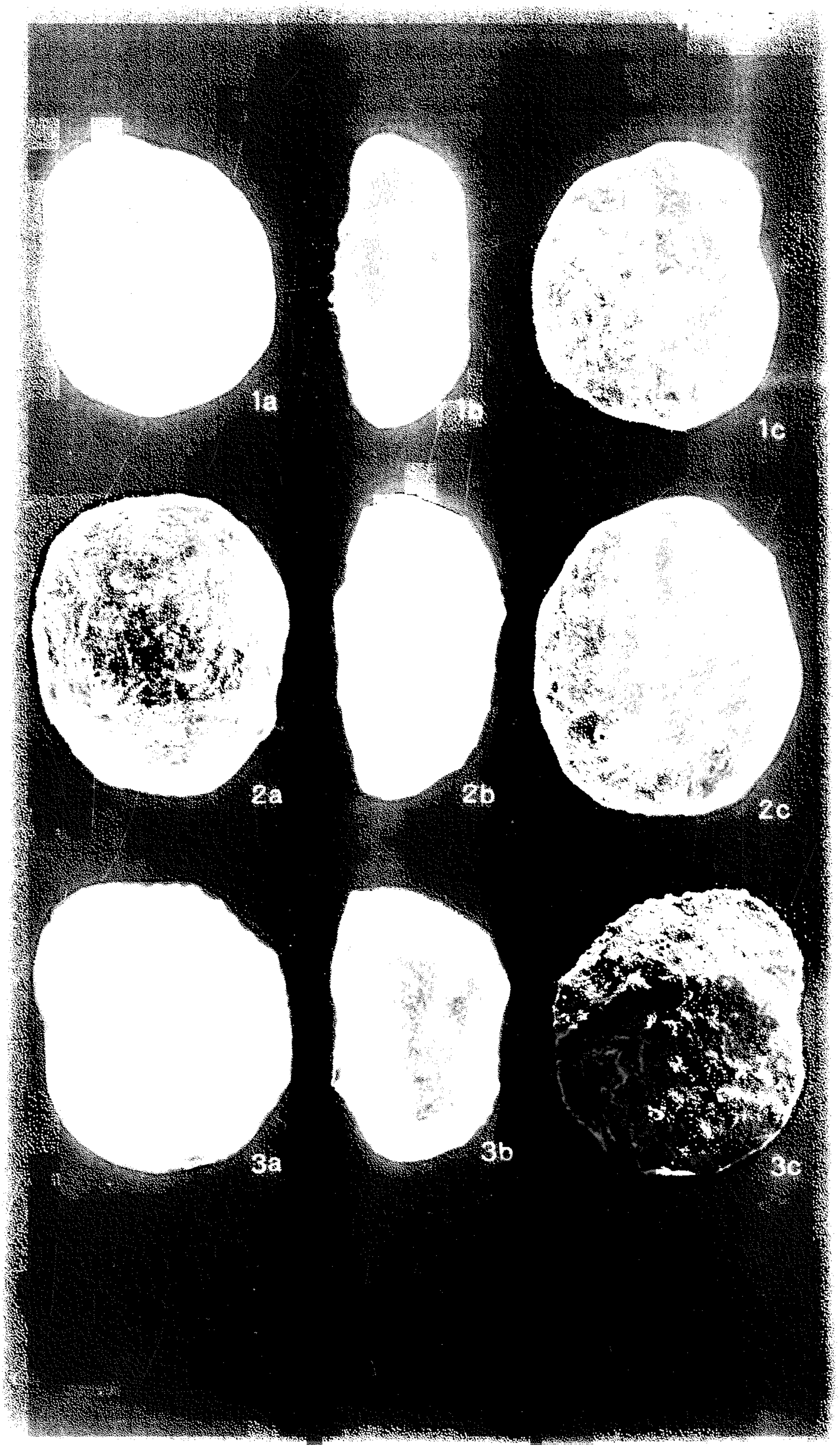

1a
1b
1c
2a
2b
2c
3a
3b
3c

Plate 26

1. Verneuilina muensteri Reuss, DSDP/33, Site 551, Core 4, Section 1, 97-102cm, x 167.

2. Tritaxia tricarinata (Reuss), DSDP/21, Site 551, Core 2, Section 3, 82-86cm, x 124.

3. Arenobulimina obliqua (d'Orbigny), DSDP/28, Site 549, Core 22, Section 1, 46-48cm, x 127.

4. Marssonella conoidea (Marie), DSDP/30, Site 551, Core 3, Section 2, 105-107cm.

   (a) side view x 113
   (b) apertural view x 113

5. Marssonella trochus (d'Orbigny), DSDP/29, Site 549, Core 22, Section 1, 46-48cm.

   (a) side view x 113
   (b) apertural view x 113

6. Ataxophragmium variabile (d'Orbigny), DSDP/15, Site 548A, Core 30, Section 1, 104-106cm.

   (a) apertural view x 133
   (b) side view x 133

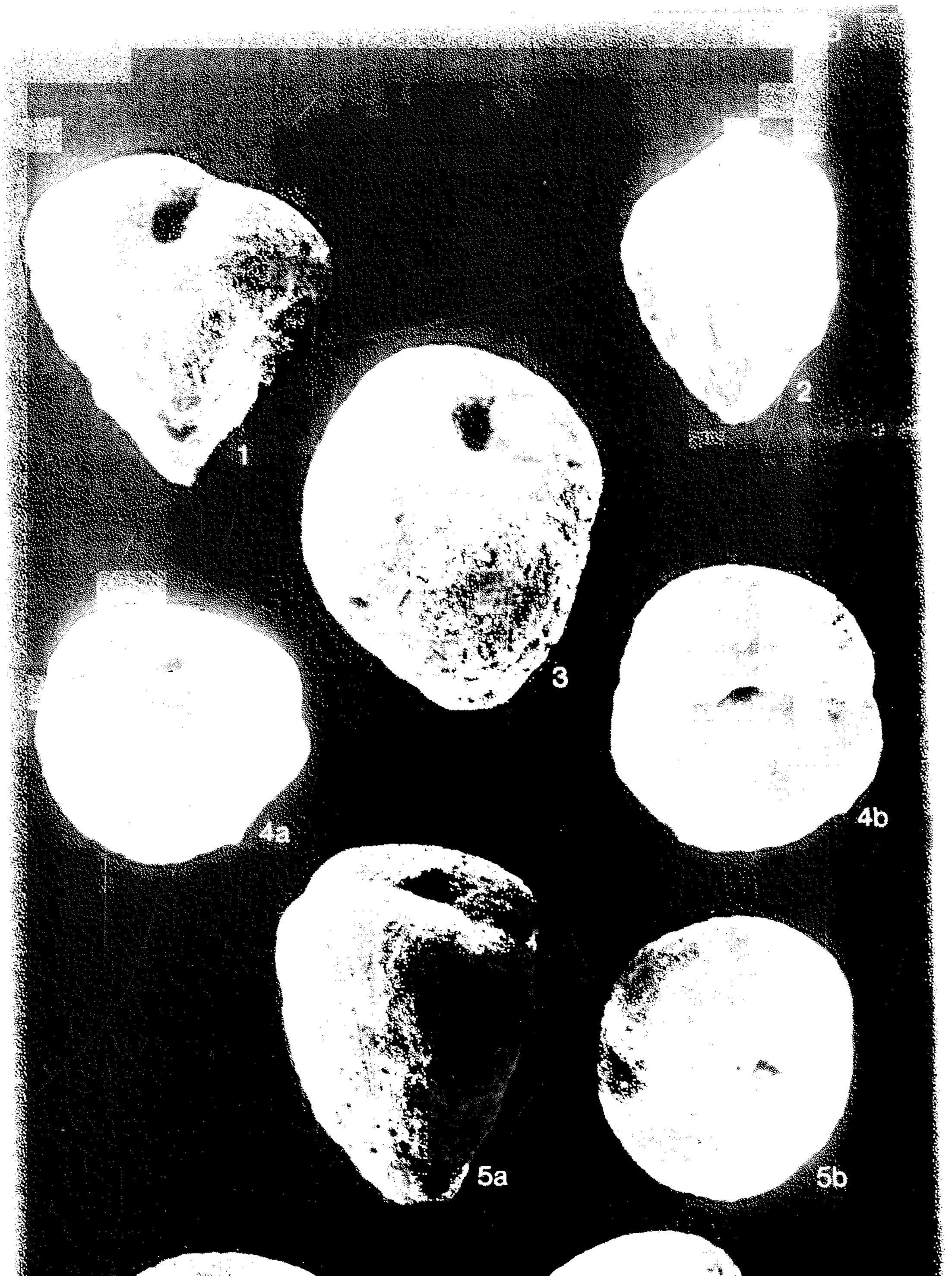

1
2
3
4a
4b
5a
5b
6a
6b

Plate 27

1. Praebulimina laevis (Beissel), DSDP/19, Site 548A, Core 29, Section 1, 70-72cm.

    (a) apertural view x 167

    (b) side view x 93

2. Bolivina incrassata Reuss, DSDP/09, Site 548A, Core 32, Section 1, 78-80cm, side view x 52.

3. Bolivinoides draco (Marsson), DSDP/20, Site 548A, Core 31, Section 3, 65-67cm, side view x 160.

4. Bolivinoides peterssoni Brotzen, DSDP/31, Site 548A, Core 32, Section 1, 78-80cm, side view x 167.

5. Reussella szajnochae szajnochae (Grzybowski), DSDP/25, Site 551, Core 3, Section 2, 105-107cm, side view x 160.

6. Pseudouvigerina cristata (Marsson), DSDP/25, Site 549, Core 22, Section 5, 47-49cm.

    (a) apertural view x 160

    (b) side view x 160

7. Eponides beisseli Schijfsma, DSDP/26, Site 551, Core 4, Section 4, 42-47cm.

    (a) umbilical view x 180

    (b) side view x 180

8. Cibicides beaumontianus (d'Orbigny), DSDP/12, Site 548A, Core 29, Section 4, 70-72cm.

    (a) umbilical view x 127

    (b) spiral view x 127

9. Cibicides ribbingi Brotzen, DSDP/27, Site 548A, Core 29, Section 4, 70-72cm.

    (a) umbilical view x 93

    (b) spiral view x 120

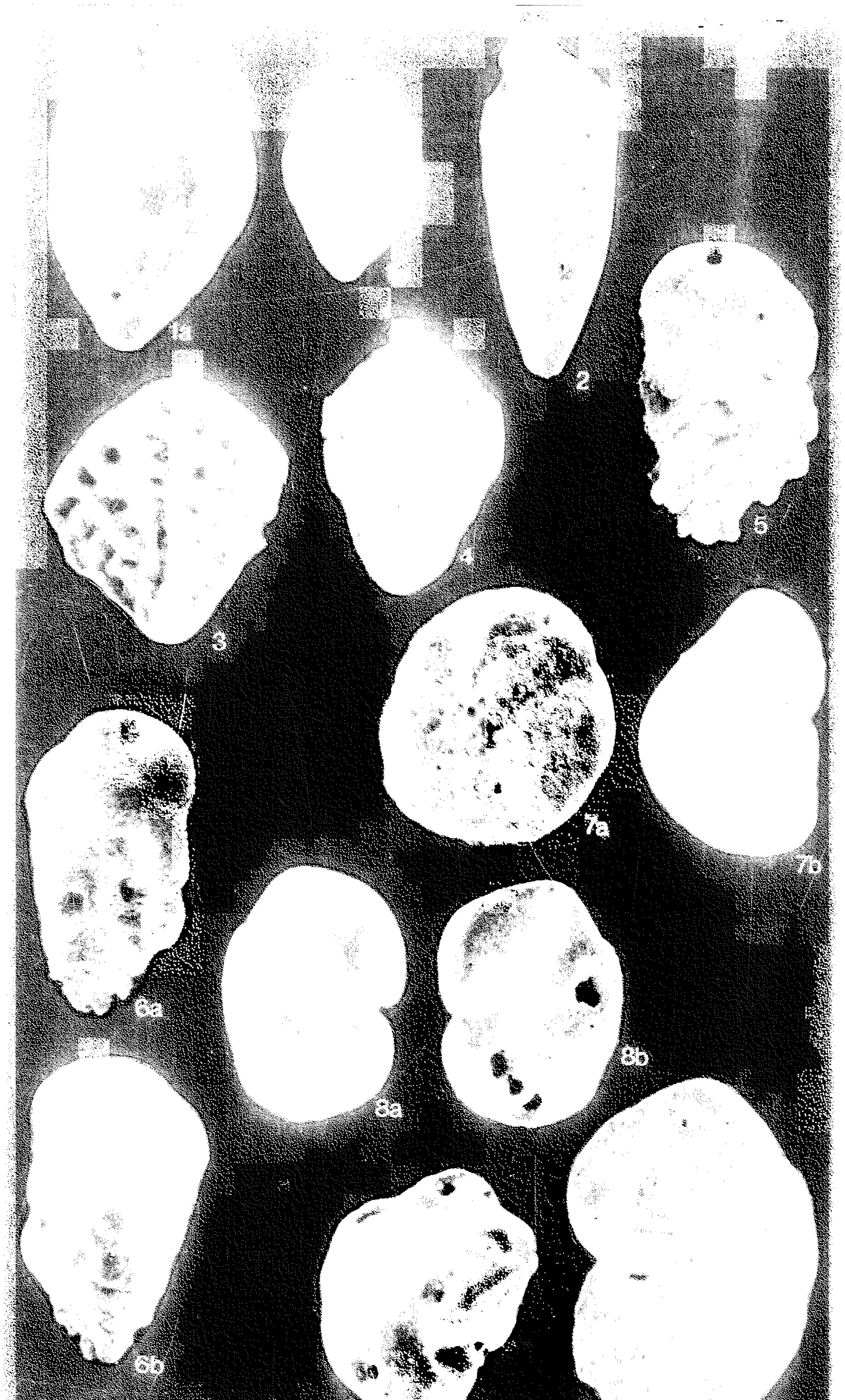

1a
1b
2
3
4
5
6a
6b
7a
7b
8a
8b
9a

Plate 28

1. Racemigumbelina fructicosa (Egger), DSDP/16, Site 549, Core 22, Section 1, 46-48cm.

(a) side view x 127

(b) apertural view x 127

2. Globigerinelloides multispina (Lalicker), DSDP/22, Site 551, Core 2, cc.

(a) side view x 167

(b) apertural view x 160

3. Shackoina multispinata (Cushman & Wickenden), DSDP/34, Site 551, Core H2, cc, x 180.

4. Globotruncanella havanensis (Voorwijk), DSDP/11, Site 548A, Core 23, Section 1, 6-9cm.

(a) spiral view x 133

(b) side view x 133

(c) umbilical view x 133

5. Abathomphalus mayaroensis (Bolli), DSDP/07, Site 549, Core 23, Section 2, 49-52cm.

(a) spiral view x 113

(b) side view x 120

(c) umbilical view x 120

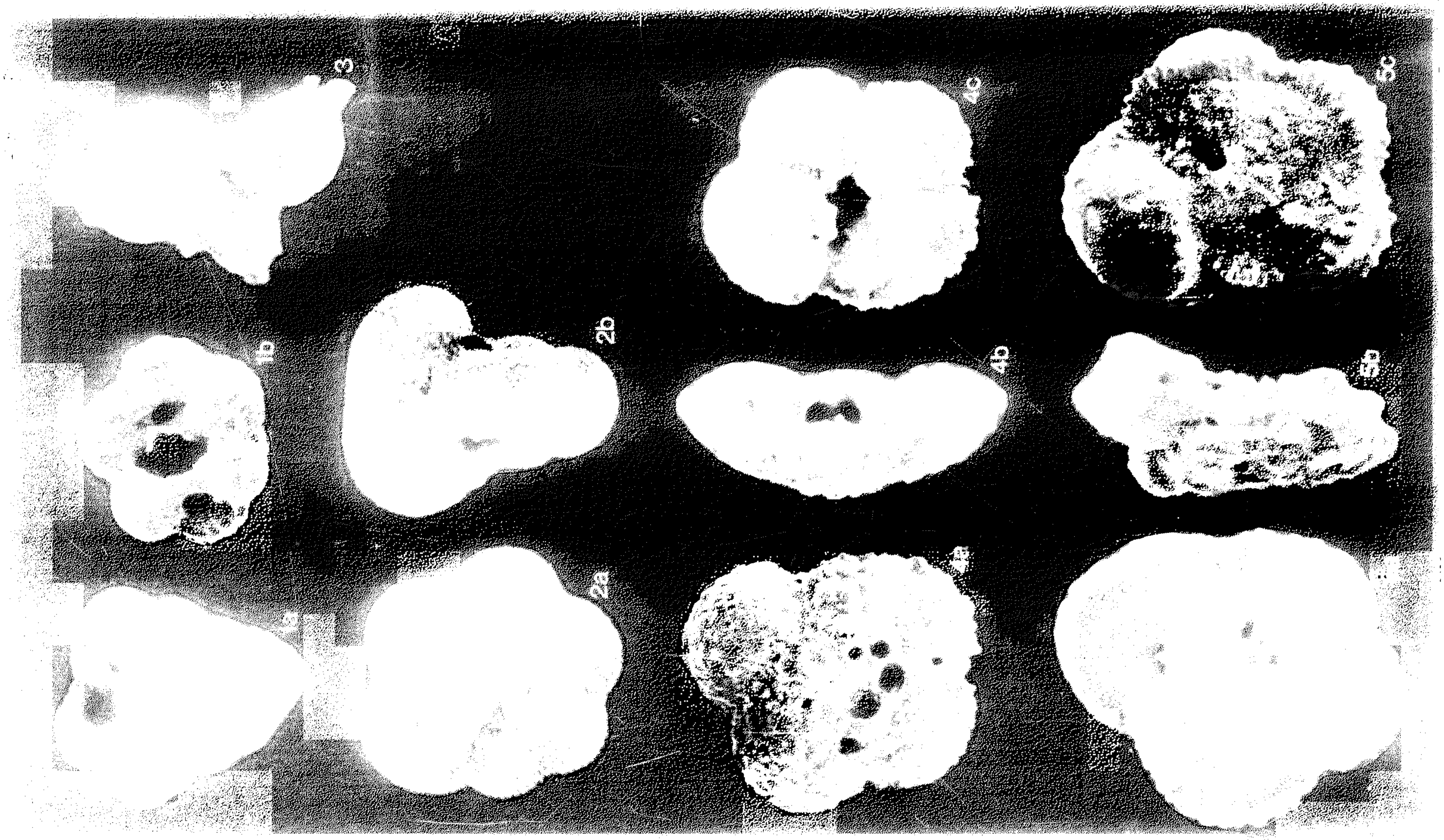

1a
1b
2a
2b
3
4a
4b
5
6

Plate 29

1. Globotruncana arca (Cushman), DSDP/04, Site 551, Core 3, Section 1, 103-105cm.

(a) spiral view x 120
(b) side view x 120
(c) umbilical view x 120

2. Globotruncana bulloides (Vogler), DSDP/38, Site 549, Core 23, Section 2, 49-52cm.

(a) spiral view x 160
(b) side view x 167
(c) umbilical view x 160

3. Globotruncana contusa (Cushman), DSDP/01, Site 548A, Core 29, Section 1, 70-72cm.

(a) spiral view x 113
(b) side view x 113
(c) umbilical view x 120

1a
1b
1c
2a
2b
2c
3a
3b
3c

Plate 30

1. Globotruncana fornicata Plummer, DSDP/35, Site 549, Core 23, Section 5, 130-133cm.

(a) spiral view x 127

(b) side view x 127

(c) umbilical view x 127

2. Globotruncana linneiana (d'Orbigny), DSDP/03, Site 548A, Core 30, Section 3, 104-106cm.

(a) spiral view x 113

(b) side view x 120

(c) umbilical view x 120

3. Globotruncana patelliformis Gandolfi, DSDP/36, Site 548A, Core 34, Section 7, 27-29cm.

(a) spiral view x 100

(b) side view x 100

(c) umbilical view x 100

4. Globotruncana plummerae Gandolfi, DSDP/37, Site 549, Core 23, Section 2, 49-52cm.

(a) spiral view x 140

(b) side view x 140

(c) umbilical view x 140

1a
2a
3a
4a
1b
2b
3b
4b

Plate 31

1. Globotruncana stuarti (de Lapparent), DSDP/18, Site 548A, Core 29, Section 4, 70-72cm.

(a) spiral view x 140

(b) side view x 133

(c) umbilical view x 140

2. Globotruncana stuartiformis Dalbiez, DSDP/17, Site 548A, Core 35, Section 1, 47-49cm.

(a) spiral view x 133

(b) side view x 133

(c) umbilical view x 120

3. Globotruncana ventricosa White, DSDP/02, Site 551, Core H2, Section 5, 46-51cm.

(a) spiral view x 93

(b) side view x 93

(c) umbilical view x 93

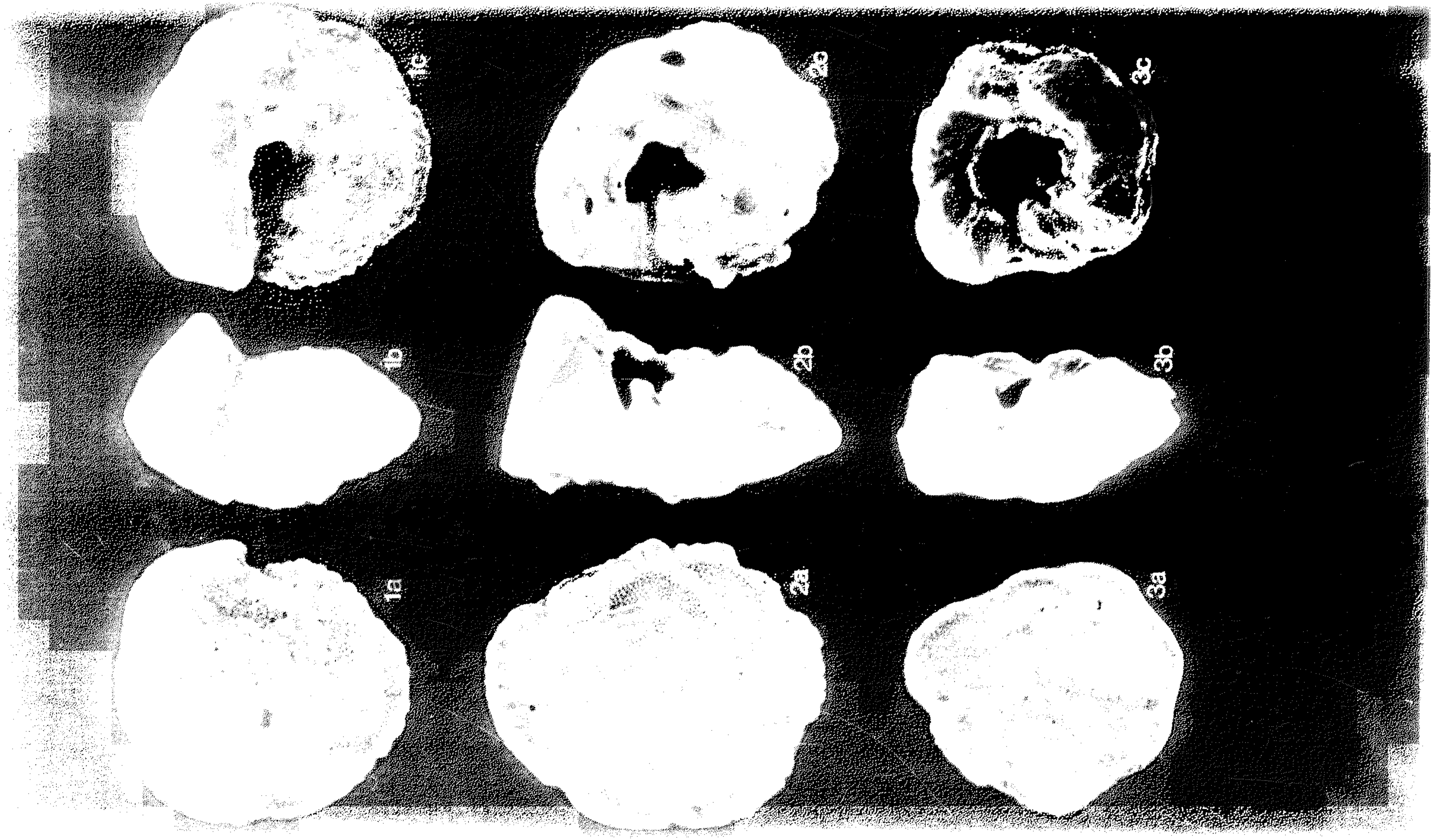

1a
1b
1c
2a
2b
2c
3a
3b
3c

Plate 32

1. Rugoglobigerina rugosa (Plummer), DSDP/24, Site 549, Core 22, Section 5, 47-49cm.

(a) spiral view x 140

(b) side view x 140

(c) umbilical view x 140

2. Rugoglobigerina milamensis Smith & Pessagno, DSDP/23, Site 549, Core 22, Section 5, 47-49cm.

(a) spiral view x 140

(b) side view x 140

(c) umbilical view x 120

2b
2c
2d
2e

Plate 33

1. Pullenia reussi Cushman & Todd, DSDP/14, Site 548A, Core 32, Section 1, 78-80cm.

(a) side view x 133

(b) apertural view x 133

2. Gyroidinoides nitida (Reuss), DSDP/32, Site 548A, Core 33, Section 1, 6-9cm.

(a) umbilical view x 160

(b) apertural view x 153

(c) spiral view x 160

3. Gavelinella pertusa (Marsson), DSDP/05, Site 548A, Core 30, Section 1, 104-106cm.

(a) umbilical view x 120

(b) apertural view x 120

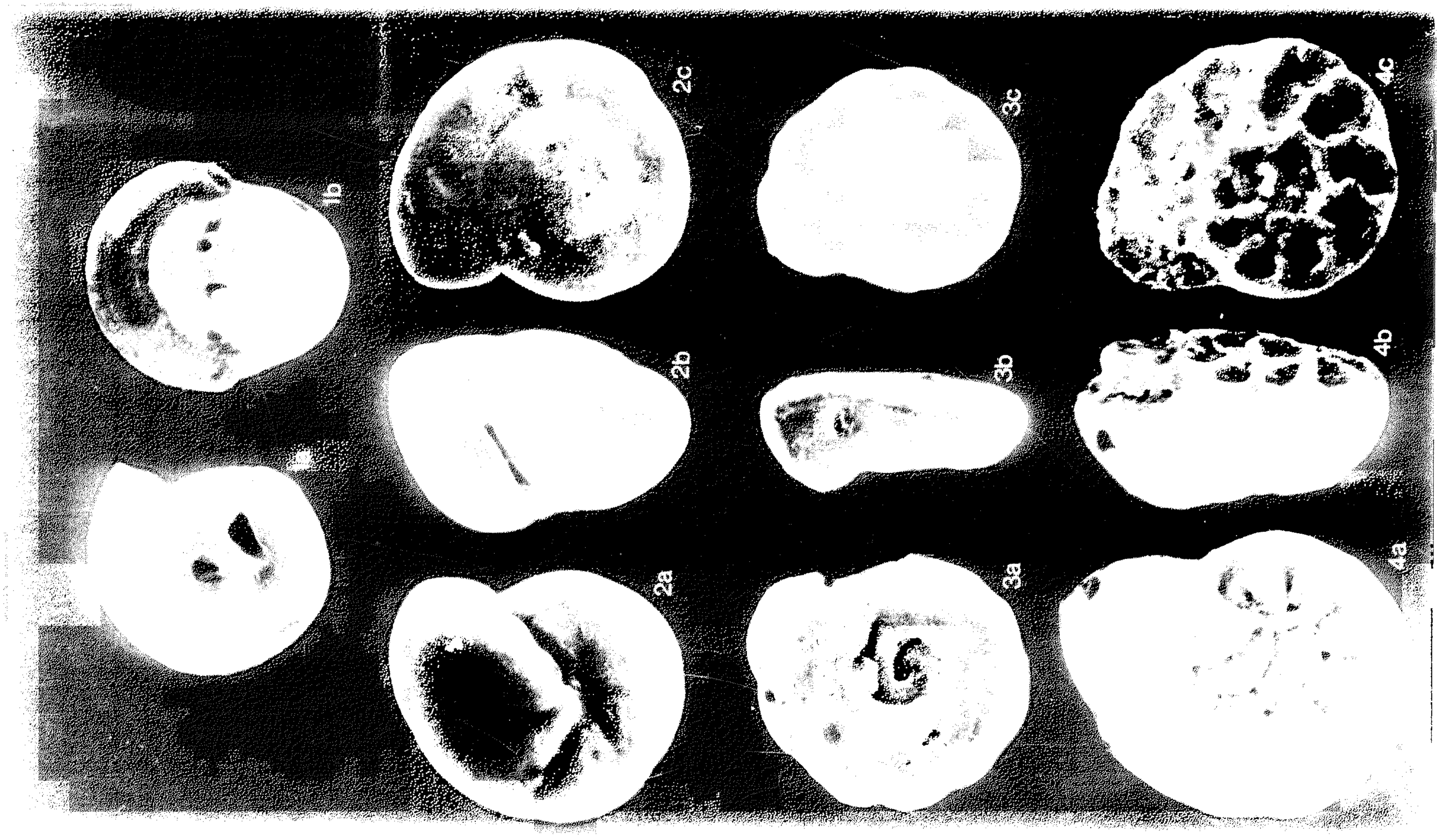
(c) spiral view x 120

4. Stensioeina pommerana Brotzen, DSDP/08, Site 548A, Core 34, Section 7, 27-29cm.

(a) umibilical view x 173

(b) apertural view x 160

(c) spiral view x 167


1a
2a
2b
2c
3a
3b
3c
4a
4b
4c

Unusually large Late Campanian - Early Maastrichtian foraminifera from the Southern North Sea Basin

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Sandown Road, Watford, WD2 4XA

ABSTRACT - A low diversity fauna of unusually large (individuals of two to three times the normal size) agglutinated and calcareous benthonic foraminifera is recorded from the Late Campanian - Early Maastrichtian Chalk sequences of two boreholes (Shell 49/19.1 and Shell 49/20.2) in the Southern North Sea Basin. Associated planktonic species are extremely rare. This distinctive assemblage provides a useful local stratigraphical marker.

INTRODUCTION

The foraminifera of Chalk sequences from three boreholes drilled by Shell (UK) Exploration and Production Limited in the Southern North Sea Basin during 1965 - 1971 have been investigated in order to establish a local biostratigraphical zonation for the Upper Cretaceous. The boreholes are Shell 44/2.1 (54° 52' 38"N, 02° 23'35"E) on the southern edge of the Mid North Sea High, and Shell 49/19.1 (50° 23' 48"N, 02, 45' 21"E) and Shell 49/20.2 (53° 27' 26.056"N, 02° 58'15.124"E) in the Indefatigable Gas

Field (Fig.1). Geophysical logs are a major tool for correlation and analysis of such offshore sequences but where a full suite of these is not available, or where a monotonous response is produced such as that through the Chalk Group, detailed subdivision must rely heavily on micropalaeontological criteria.

FIG 1 ½ PAGE

Most borehole samples from offshore are generally available only as "ditch cuttings" which are tiny chips of rock cut by the drill bit. In the present study, these were sampled at 30ft. intervals. The cuttings are brought to the surface by drilling mud that is circulated to lubricate the drill bit and to prevent the well caving in. One of the several problems encountered when ditch cuttings are used in biostratigraphical studies is that of "cavings" which is material introduced into the mud system from stratigraphical levels higher up the well. To compensate for this, biostratigraphical and chronostratigraphical boundaries are drawn at extinctions (i.e. first down-hole appearances) of fossil taxa. The Upper Cretaceous stage boundaries in the three boreholes examined have been established on this basis using the known foraminiferal ranges from onshore Britain and elsewhere in Europe. These boundaries are shown, together with the geophysical log signatures (Gamma Ray and Formation Density) for Borehole 49/20.2 in Fig.2.

FIG 2 WHOLE PAGE

SAMPLE PREPARATION AND EXAMINATION

Each sample was disaggregated in white spirit, washed through a 75 μm sieve, dried and then split into four size fractions in a nest of sieves (500 μm, 250-500 μm, 180'-250 μm, 125-180 μm).

The 500 μm fraction of the samples from 1,500ft. - 2,000 ft. in Borehole 49/19.1 and 2870 ft. - 3800 ft. in Borehole 49/20.2 yielded extraordinarily large specimens (see Pl.1. figs 5a, b) of a low diversity fauna of agglutinated and calcareous benthonic foraminifera (see below). Only rare planktonic forms were recorded. This unusual assemblage was not recovered from Borehole 44/2.1.

NOTES ON TAXA

Arenobulimina courta (Marie) Pl.1, fig.1

This species was described originally from the Campanian (mucronata Zone) of the Paris Basin (Marie 1941). The test is free and globular; the chambers are arranged trochospirally in three to four whorls and are inflated to very inflated in the last whorl which makes up over half of the test. The sutures are distinct and depressed, and the aperture is a single slit or semi-circular opening midway along the internal margin of the last chamber at the junction of the four sutures of the final whorl. The wall is thick and the surface rugose. The species has been compared with Bulimina obesa Reuss, first described from the Upper Cretaceous of Poland, but the relationship between the two species remains unclear.

Average size: Height : 0.63mm
Width : 0.49mm

Bigger forms: Height : 1.3mm
Width : 1.0mm

Arenobulimina elevata (d'Orbigny) Pl.1, fig.2.

This species was described originally from the Campanian of the Paris Basin (d'Orbigny 1840) and is very similar to A. courta (see above). However, it may be distinguished by its bigger size (four to five whorls) and high trochospire.

Average size: Height : 1.3mm
Width : 1.1mm

Bigger forms: Height : 2.0mm
Width : 1.7mm

Eggerellina brevis (d'Orbigny) Pl.1, fig.3.

This species was described originally from the Campanian of the Paris Basin (d'Orbigny 1840). It shows a wide range of morphological variation and well documented dimorphism (microspheric and megalospheric forms). However, its taxonomic history is rather confused. The type figures show clearly the characteristic dominance of the last overlapping whorl, the trilobed appearance and the 'key-hole' shaped aperture. Two and a half chambers are usually visible from the summit. The wall is agglutinated but composed of calcareous particles.

Average size: Height : 0.56mm
Width : 0.49mm

Bigger forms: Height : 1.17mm
Width : 0.96mm

Ataxophragmium rimosum (Marsson) Pl.1, fig.4.

This species was described originally from the Chalk of Rügen Island, East Germany (Marsson 1878). The test is free and subspherical; the chambers are arranged in a tightly coiled helical spire of two to three distinctly overlapping whorls and are obscured by the strong ornamentation of randomly arranged grooves which roughen the surface and distinguish the species from other members of the genus. The grooves may be the result of dissolution of the sponge spicules that were once cemented together to form the test. The sutures are flush, and the aperture varies from a simple semi-circular interiomarginal opening on the final chamber to a narrow slit extending up the apertural face.

Average size: Height : 0.53mm
Width : 0.49mm

Bigger forms: Height : 0.83mm
Width : 0.77mm

Ataxophragmium variabile (d'Orbigny) Pl.1, figs 5a,b

This species was described originally from the Campanion of the Paris Basin (d'Orbigny 1840) and is type of the genus Ataxophragmium. It is a highly variable form with a free test which is subglobular to elongate with a variable outline but always broader than high. The chambers are arranged in a helical spire of two to three loosely to tightly coiled overlapping whorls. The sutures are flush to slightly depressed. The aperture is usually a simple semi-circular opening at the inner margin of the last chamber, but it may vary in form and be a narrow, elongate slit that extends up the apertural face which is always flattened. The wall is thick and the surface smooth or slightly rugose. The considerable morphological variation shown by this species has resulted in much taxonomic confusion and in the past, certain variants have been accommodated in other, sometimes new, genera (e.g. Orbignyna, Ataxogyroidina) and species (e.g. concava Marie, cylindrica Marie, gibbosa Marie, ovoidea Marie).

Average size: Height : 0.34mm
Width : 0.31mm

Bigger forms: Height : 0.91mm
Width : 0.86mm

Ataxophragmium sp. nov. A Pl.9, fig.6

This species has a free, asymmetrical test which is sometimes subspherical tending to plano-convex. The chambers are indistinct, slightly inflated and higher than broad, and are arranged trochospirally usually in two (but sometimes in up to three) overlapping evolute whorls. There are six chambers per whorl and the last chamber of each tends to overlap the

previous whorl. The sutures are distinct and flush. The aperture is a simple, sub-rectangular, deep slit extending along the interiomarginal suture of the last chamber; the apertural face is flattened. The wall is thick and finely agglutinated with much calcareous cement; the surface is smooth.

Marie (1941) referred an identical form from the Campanian (mucronata Zone) of the Paris Basin to Nonionina globulosa von Hagenow 1842. However, several authors (e.g. Marsson 1878, Cushman 1931, Visser 1951) have concluded that von Hagenow's unfigured species was based on a calcareous perforate form, not an agglutinated form. Therefore, Marie's species and the present form cannot be accommodated with globulosa and a new specific name is required. Sweicicki (unpublished thesis 1980) created the new species mariae for it, but until this taxon is published formally, the identification Ataxophragmium sp. nov.A. is favoured.

Average size: Height : 0.72mm
Width : 0.64mm

Bigger forms: Height : 1.2mm
Width : 1.05mm

Orbignyna ovata von Hagenow Pl.1, fig.7.

This species was described originally from the Chalk of Rügen Island, East Germany (von Hagenow 1842). The test is free, elongate and compressed. The chambers are indistinct and uninflated; the first five or six are arranged in a broadly rounded planispiral coil and are strongly overlapping on the inner coiled margin but later, they expand moderately and uniformly and the coil becomes evolute with the last chamber or two being partially uncoiled. The sutures are initially indistinct but later distinct, depressed and curved. The apertural face is weakly inflated with a

distinct depression about the aperture which is a simple, terminal circular to elliptical pit. The wall is coarsely agglutinated and the surface is roughened by many longitudinal grooves as in Ataxophragmium rimosum (see above).

Average size: Height : 0.88mm
Width : 0.66mm

Bigger forms: Height : 1.4mm
Width : 1.2mm

Orbignya sherlocki Barnard Pl.1, fig.8

This species was described originally from the Campanian (mucronata Zone) of Council's Pit, Newmarket Road, Norwich, Norfolk (Barnard 1953). It is distinguished from O. ovata (see above) by its conical form, circular and weakly inflated apertural face, and moderately rugose surface.

Average size: Height : 0.62mm
Width : 0.44mm

Bigger forms: Height : 1.1mm
Width : 1.02mm

Cibicidoides (?) voltziana (d'Orbigny) Pl.1, fig.9

This species was described originally from the Upper Campanian of the Paris Basin and England (d'Orbigny 1840). The characteristic large plano-convex test with prominent calcite bosses make this species distinctive although its generic position is unclear. It has been referred to a number of genera including Cibicides, Cibicidoides, Gavelinella and Gavelinopsis, all of which display similarities in basic morphology but differ in their test wall structure. Most foraminiferal tests from the Upper Chalk have undergone fine-scale recrystallisation resulting in a secondary heterogeneous granular wall structure (Reiss 1959; Schlanger and Douglas

1974) and therefore the true generic position of this species cannot be established; study of unrecrystallised material may clarify the position.

Average size: Diameter : 0.51mm
Height : 0.22mm

Bigger forms: Diameter : 1.02mm
Height : 0.45mm

Lenticulina spp. Pl.1, figs 10,11

The unornamented Lenticulina are in most cases nearly impossible to speciate. They have long stratigraphical ranges which reduces their potential as useful biostratigraphic indicators and in the present study, no effort was made to determine them beyond generic level.

Average size: Diameter 1 : 0.59mm
Diameter 2 : 0.51mm

Bigger forms: Diameter 1 : 1.77mm
Diameter 2 : 1.54mm

CONCLUSIONS

The low diversity but dominant fauna of unusually large benthonic foraminifera described above has been recorded from the same stratigraphical interval in the two boreholes studied from Block 49 - Shell 49/19.1 and Shell 49/20.2. It is suggested that the occurrence of this distinctive assemblage provides a useful local stratigraphical marker.

All chronostratigraphical and biostratigraphical interpretations were based on down-hole appearances which have been related to known foraminiferial ranges from onshore Britain and elsewhere in Europe (e.g. Koch 1977; Sweicicki 1980 (unpubl.); Hart et al. 1981). The assemblage is dated as Early Maastrichtian - Late Campanian because of the down-hole appearances of the Maastrichtian forms Osangularia navarroana (Cushman), Praebulimina

laevis (Beissel) and the planktonic Rugoglobigerina rugosa (Plummer) together with Arenobulimina elevata (d'Orbigny), Bolivinoides laevigatus Marie, B. miliaris Hiltermann & Koch, Cibicidoides (?) voltziana (d'Orbigny), Orbignyna ovata von Hagenow, O. sherlocki Barnard and Praebulimina obtusa (d'Orbigny), followed by the Late Campanian forms Gavelinella monterelensis (Marie), Globorotalites hiltermanni Kaever, Globorotalites micheliniana (d'Orbigny), Osangularia cordieriana (d'Orbigny) and rarely the planktonic Archaeoglobigerina cretacea (d'Orbigny).

ACKNOWLEDGEMENTS

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Finally, I am indebted to Dr. Beris M. Cox (B.G.S., Keyworth) for her invaluable help and enthusiasm during the preparation of this paper.

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EXPLANATION OF PLATE 1

All figures are x 35. Specimen numbers refer to the collections of the British Geological Survey (Keyworth).

Fig. 1. Arenobulimina courta (Marie): apertural view, MPK 4088; Shell 49/20.2, 3650 ft.

Fig. 2. Arenobulimina elevata (d'Orbigny): apertural view, MPK 4089; Shell 49/20.2, 3590ft.

Fig. 3. Eggerellina brevis (d'Orbigny): apertural view, MPK 4090; Shell 49/20.2, 3020ft.

Fig. 4. Ataxophragmium rimosum (Marsson): apertural view, MPK 4091; Shell 49/20.2, 3020ft.

Fig. 5. Ataxophragmium variabile (d'Orbigny):

a) apertural view, MPK 4092; Shell 49/20.2, 3620ft.

b) apertural view, MPK 4093; Shell 44/2.1, 3360ft. 'normal' size

Fig. 6. Ataxophragmium sp. nov. A: apertural view, MPK 4094; Shell 49/20.2, 3230ft.

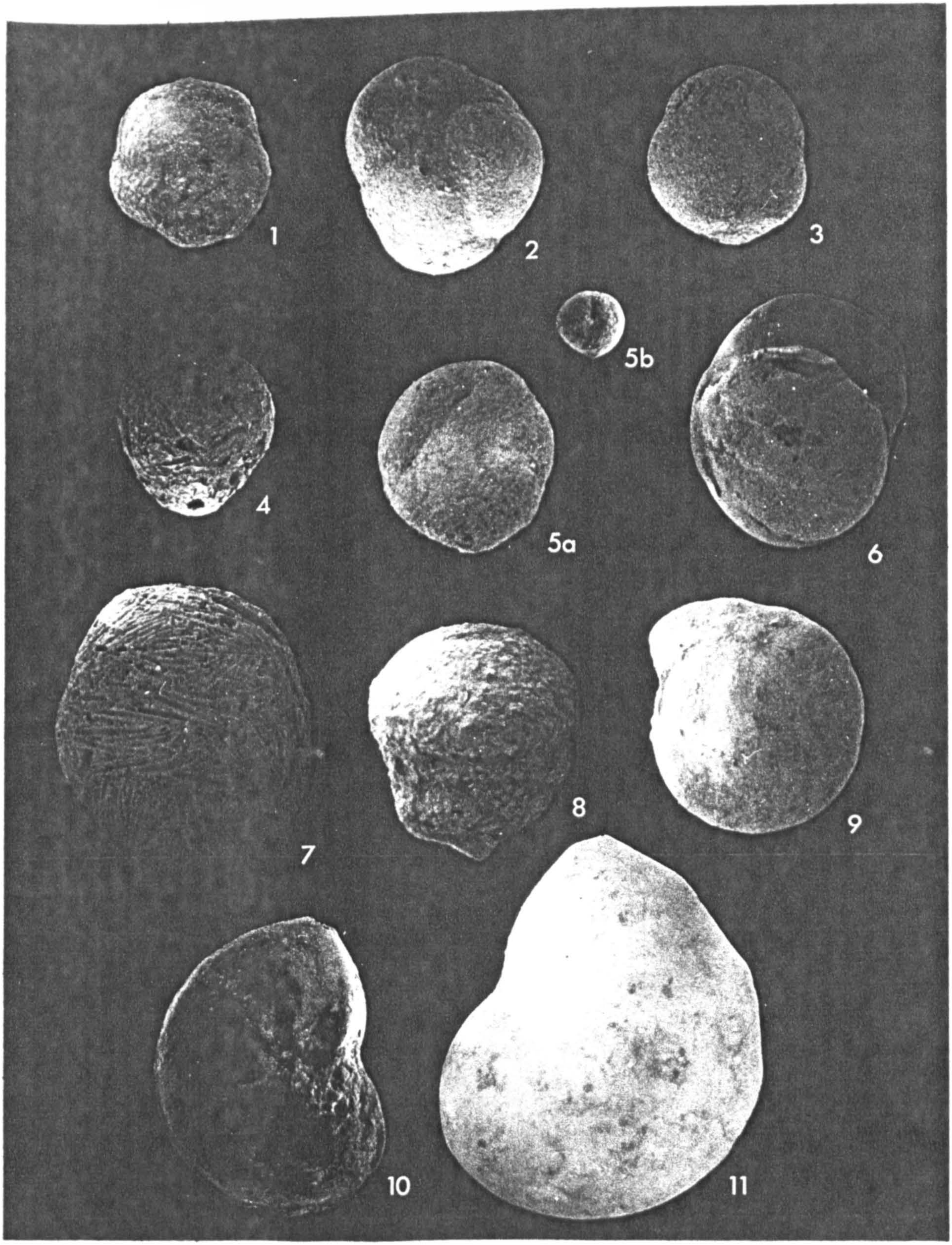
Fig. 7. Orbignyna ovata von Hagenow: side view, MPK 4095; Shell 49/20.2, 3200ft.

Fig. 8. Orbignyna sherlocki Barnard: side view, MPK 4096; Shell 49/20.2, 3620ft.

Fig. 9. Cibicidoides (?) voltziana (d'Orbigny): spiral view, MPK 4097; Shell 49/20.2, 3200ft.

Fig.10. Lenticulina sp.: side view, MPK 4098; Shell 49/20.2, 3620ft.

Fig.11. Lenticulina sp.: side view, MPK 4099; Shell 49/20.2, 3590ft.


1
2
3
5b
4
5a
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10
11

Fig. 1. Location of the three boreholes in the Southern North Sea Basin used in this study.

Fig. 2. Stratigraphical interpretation of the Chalk sequence in Shell 49/20.2.

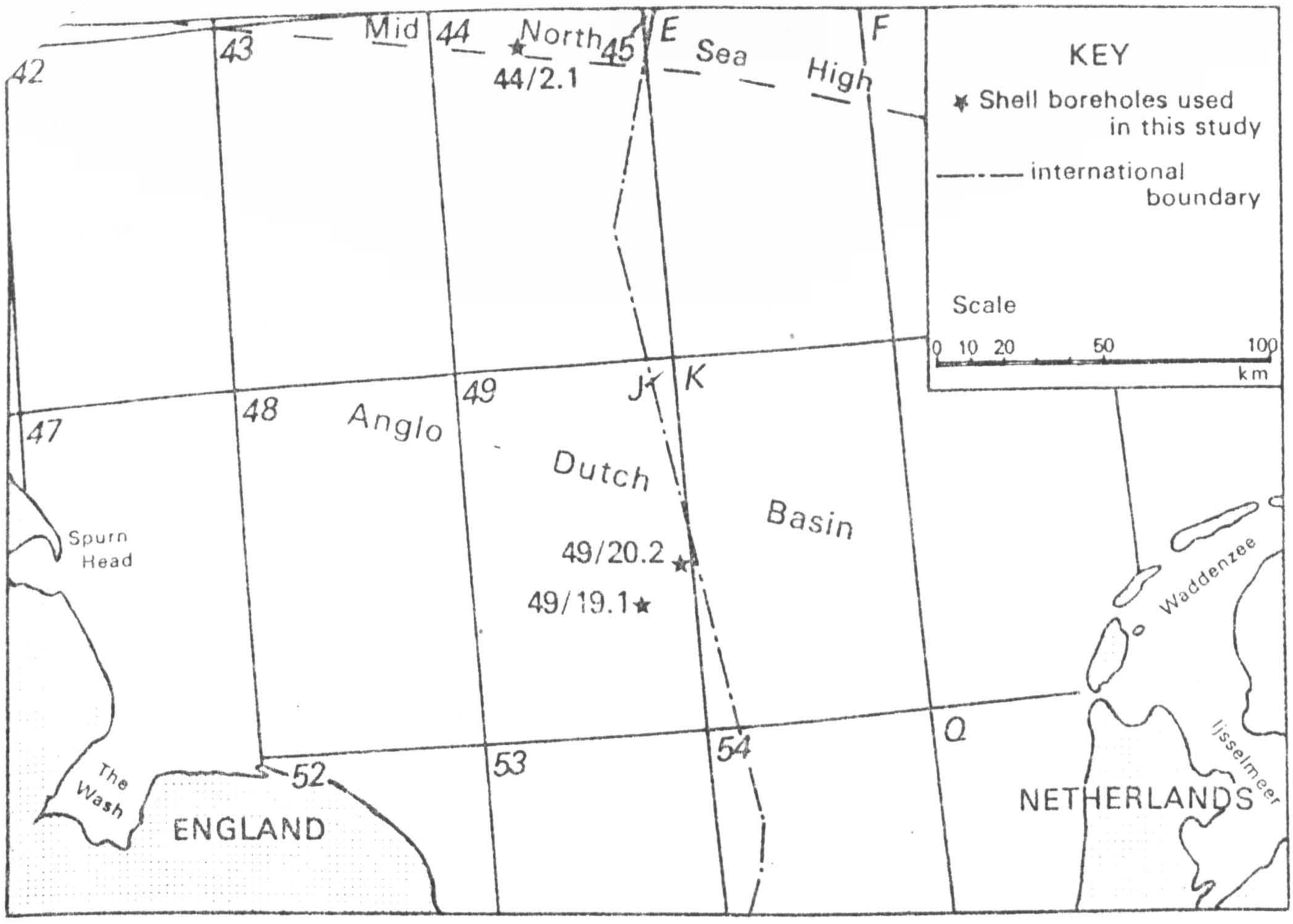
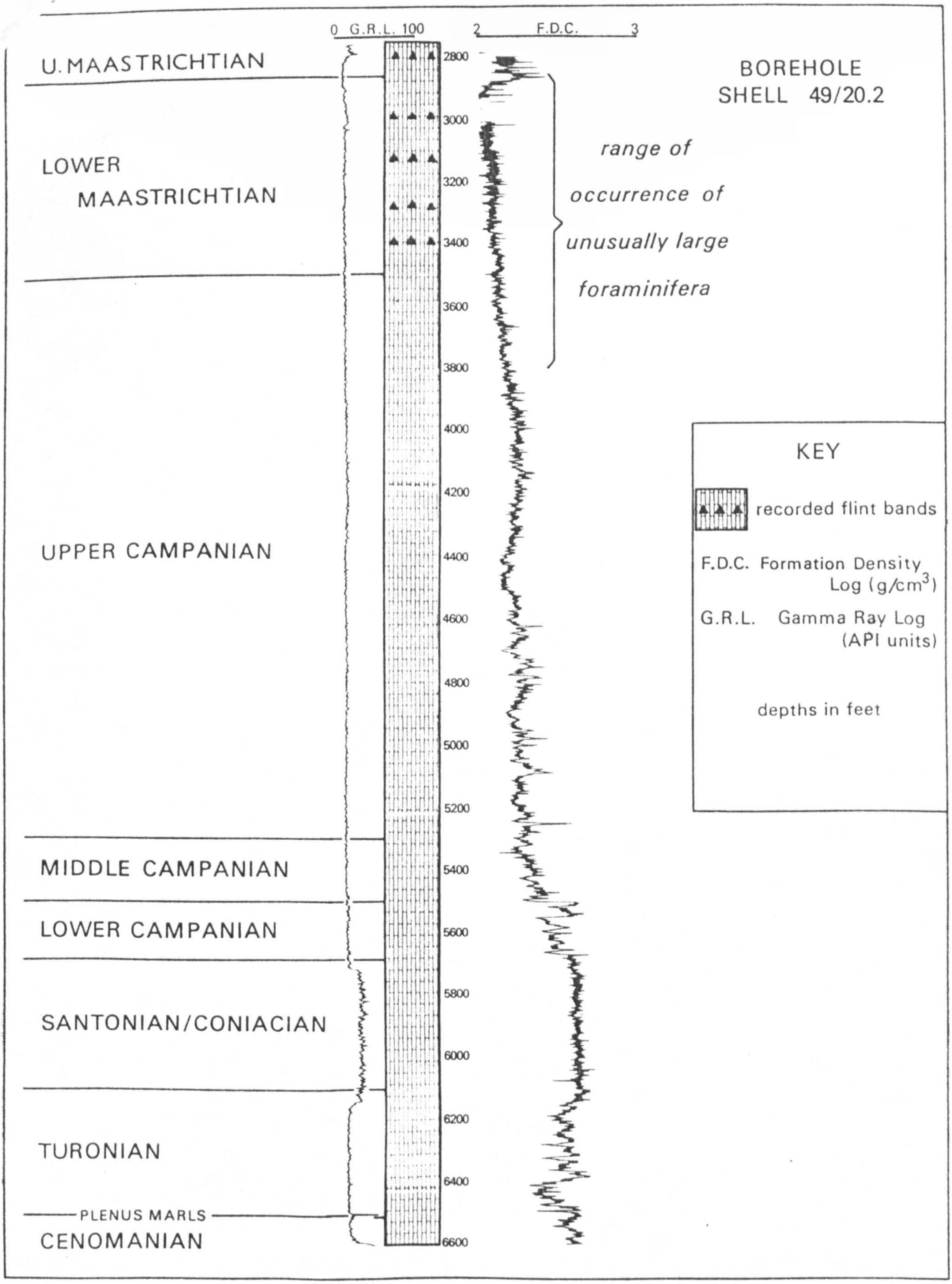


Fig. 1 Location of the three boreholes in the Southern North Sea Basin used in this study


0 G.R.L. 100
2 F.D.C. 3
U. MAASTRICHTIAN
LOWER MAASTRICHTIAN
UPPER CAMPANIAN
MIDDLE CAMPANIAN
LOWER CAMPANIAN
SANTONIAN/CONIACIAN
TURONIAN
PLENUS MARLS
CENOMANIAN
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
6000
6200
6400
6600
range of occurrence of unusually large foraminifera
BOREHOLE SHELL 49/20.2
KEY
recorded flint bands
F.D.C. Formation Density Log (g/cm3)
G.R.L. Gamma Ray Log (API units)
depths in feet

The foraminifer *Vaginulinopsis scalariformis*—a new record from the Santonian (Cretaceous) of the southern North Sea Basin.

Kim C. Ball

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PLATE

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Bibliographical reference

BALL, K. C. 1984 The foraminifer *Vaginulinopsis scalariformis*—a new record from the Santonian (Cretaceous) of the southern North Sea Basin. *Rep. Br. Geol. Surv.*, Vol. 16, No. 10, pp.10–12.

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SUMMARY

Vaginulinopsis scalariformis Porthault, previously described from the Lower Senonian 'Series' of south-east France and known from the Boulonnais and south-east England, is here recorded from the lower part of the Santonian of the southern North Sea Basin for the first time.

VAGINULINOPSIS SCALARIFORMIS

The calcareous benthonic foraminifer *Vaginulinopsis scalariformis* was first described from the lower Santonian of the Lower Senonian 'Series' of Puget-Théniers (Alpes-Maritimes, south-east France) by Porthault (*in* Donze and others, 1970, fig. 4). Subsequently the species was recorded from the lower Coniacian of the Boulonnais (Robaszynski and others, 1980, p. 277) and from the Lower Senonian 'Series' of south-east England (Bailey, 1978; Bailey and Hart, 1979; Hart and others, 1981, p. 153). There is no published record of this species from Germany, the Netherlands and elsewhere in north-west Europe and, compared with most other Upper Cretaceous foraminifera, it remains relatively poorly known. Despite its apparent limited geographical range, Hart and others (1981, p. 222 and fig. 7.11) suggested that it had some stratigraphical value as a marker for the lowermost Santonian. However, the position of the stage boundaries within the Lower Senonian 'Series' has fluctuated (Harland and others, 1982) and as a result some published ranges of the species may be misleading. Relative to the present position of the Coniacian–Santonian boundary (Bailey and others, 1983), the known range of *Vaginulinopsis scalariformis* is from the early Coniacian to the mid-Santonian (Figure 1).

The species is distinctive and easily recognised: the test has a compressed ovoid cross-section, and is initially a tight planispiral coil which rapidly becomes uniserial with very well developed and characteristic transverse septal ridges (Plate 1, figs. 1, 2 and 3).

The species is now recorded as a rare component in the assemblages of the lower part of the Santonian (which include *Dicarinella canaliculata* (Reuss), *Marginotruncana marginata* (Reuss), *M. pseudolinneana* Pessagno and *Stensioeina granulata granulata* (Orbertz)) of the southern North Sea Basin. Apart from extending the known geographical range, this record also helps to establish correlations between the southern North Sea Basin and the better known French sequences. The southern French foraminiferal assemblages are of Tethyan aspect and most studies have concentrated on the planktonic element of the fauna, on which global zonations tend to be based (Figure 1). Most of the other Upper Cretaceous foraminifera from the southern North Sea Basin are better known than *V. scalariformis* with plentiful figured examples from many other north-west European sequences.

The present examples of *V. scalariformis* were recovered

TEXT BOUND INTO THE SPINE

SERIES	STAGE	BRITISH BENTHONIC FORAM ZONE (Bailey et al. 1983)	RANGE OF *Vaginulinopsis scalariformis*	FRENCH PLANKTONIC FORAM ZONE (Robaszynski et al. 1980; Eur.Work.Gp Plank.Foram., in press)
SENONIAN (pars)	CAMPANIAN (pars)	*Bolivinoides culverensis* (pars)		*Globotruncana elevata*
	SANTONIAN	*Bolivinoides strigillatus*		*Dicarinella asymetrica*
		Stens. granulata perfecta		
		Stensioeina granulata polonica		
	CONIACIAN	*Stensioeina exsculpta exsculpta*		*Dicarinella concavata*
		Stens. granulata granulata		
	TURONIAN (pars)			*Marginotruncana schneegansi*

Figure 1 Table showing the stages, zones and range of *Vaginulinopsis scalariformis*

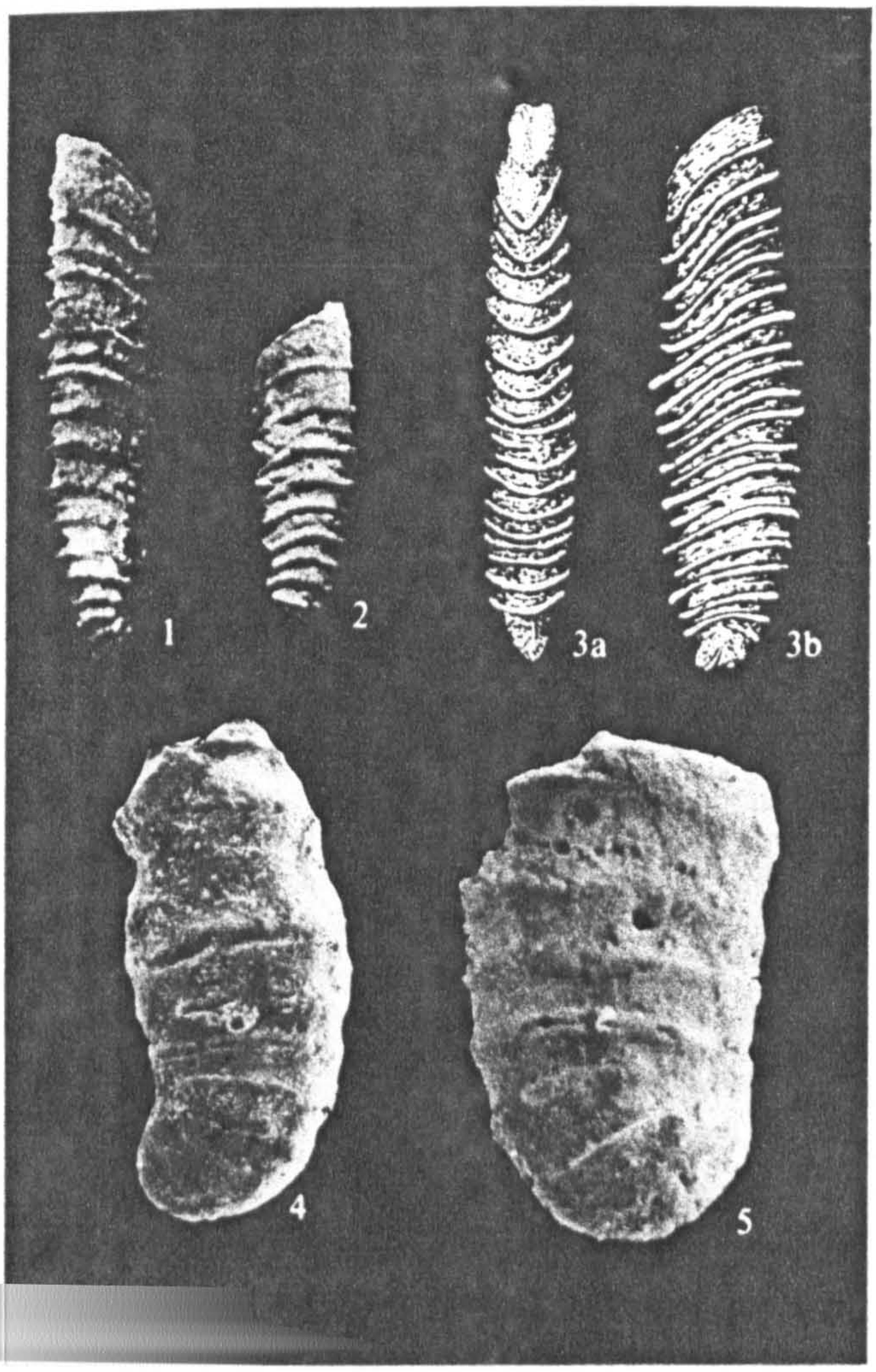

Plate 1 *Vaginulinopsis scalariformis* Porthault

1 Holotype, lateral view (× 23), as figured by Porthault (1970, pl. 8, fig. 1); lowest Santonian, Puget-Théniers area (Alpes-Maritimes), France.

2 Paratype, lateral view (× 23), as figured by Porthault (1970, pl. 8, fig. 2); lowest Santonian, Puget-Théniers area (Alpes-Maritimes), France.

3a Holotype, ventral view (× 24) as figured by Porthault (1970, text fig. 3a).

3b Holotype, lateral view (× 24), as figured by Porthault (1970, text fig. 3b).

4 Lateral view (× 35), as figured by Hart and others (1981, pl. 7.25, fig. 7); lowest Santonian, Quidhampton, Wiltshire.

5 Lateral view (× 50); lowest Santonian, Shell 49/19.1, 2510′, Southern North Sea Basin; IGS registered specimen number MPK 4031.

from ditch-cuttings from Shell 49/19.1 (53° 20′ 48″ N, 02° 45′ 21″ E). The specimens are broken and corroded (Plate 1, fig. 5) and as such they add little to our present understanding of the morphology of the species.

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KEY TO FOSSIL DISTRIBUTIONS

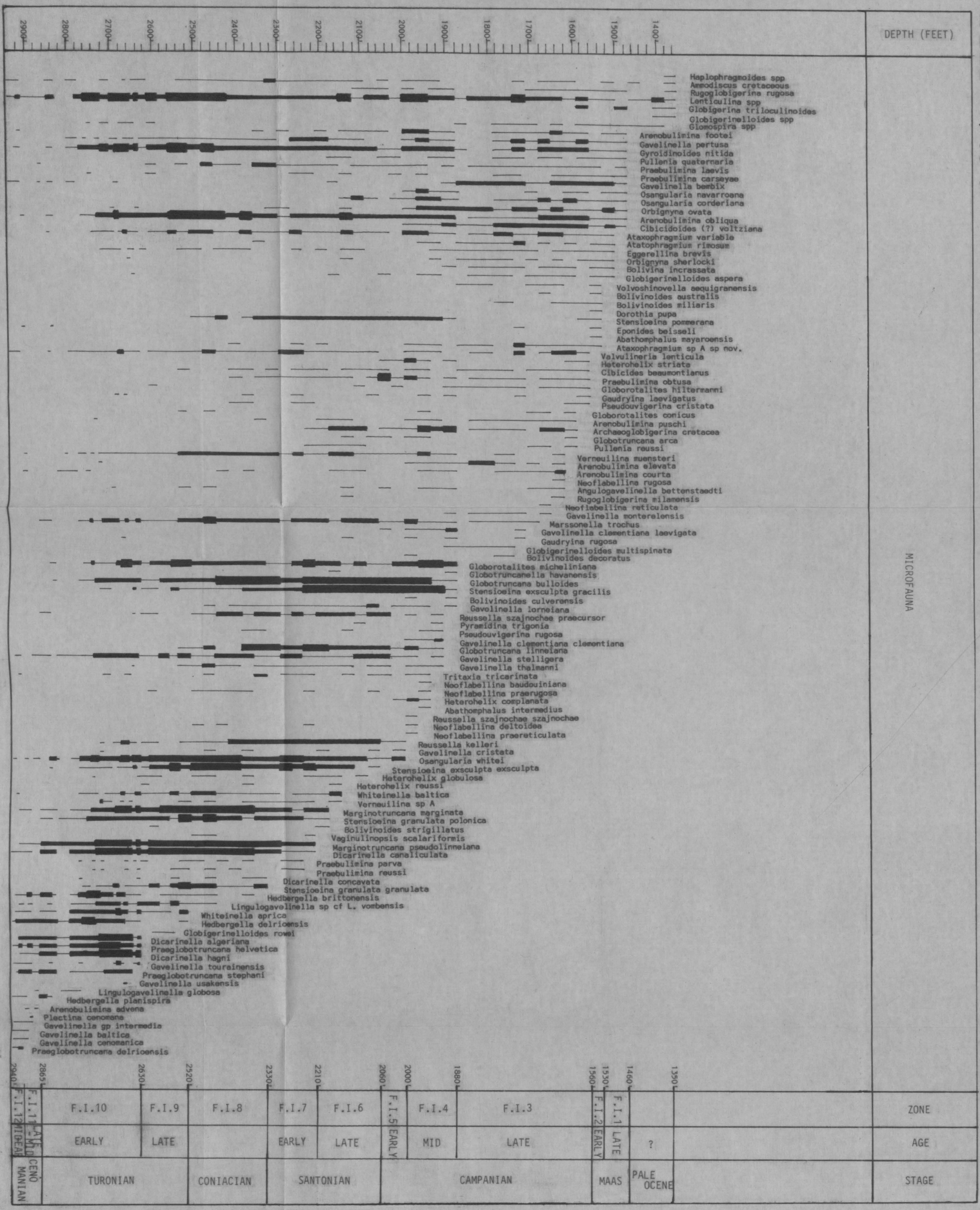
Abundant

Common

Rare

Enclosure 2 Biozonation of well 49/19-1

WELL 49/19-1



2940	2865	2630	2520	2330	2210	2060	2000	1880	1560	1530	1460	1350		
F.I.12 / F.I.11	F.I.10	F.I.9	F.I.8	F.I.7	F.I.6	F.I.5	F.I.4	F.I.3	F.I.2	F.I.1				ZONE
MIDEAR / LATE	EARLY	LATE		EARLY	LATE	EARLY	MID	LATE	EARLY	LATE	?			AGE
MANIAN / CENO	TURONIAN		CONIACIAN	SANTONIAN		CAMPANIAN			MAAS		PALE OCENE			STAGE

WELL 44/2-1

Enclosure 1 Biozonation of well 44/2-1

DEPTH (FEET)

5000 4900 4800 4700 4600 4500 4400 4300 4200 4100 4000 3900 3800 3700 3600 3500 3400 3300 3200 3100 3000

MICROFAUNA

Trochammina sp
Ammodiscus cretaceous
Glomospira spp
Pullenia quaternaria
Lenticulina spp
Haplophragmoides spp
Spiroplectammina sp
Globigerina triloculinoides
Marssonella trochus
Dorothia pupa
Bulimina midwayensis
Gavelinella pertusa
Gavelinella beccbix
Gyroidinoides nitida
Bolivina incrassata
Globigerinelloides aspera
Bolivinoides draco
Globotruncanella havanensis
Rugoglobigerina rugosa
Arenobulimina obliqua
Orbignyna ovata
Heterohelix striata
Heterohelix complanata
Stensioeina pommerana
Arenobulimina footei
Eggerellina brevis
Osangularia navarroana
Ataxophragmium variable
Tritaxia tricarinata
Cibicides beaumontianus
Rugoglobigerina milamensis
Globigerinelloides multispina
Praebulimina laevis
Bolivinoides peterssoni
Rugoglobigerina rotundata
Ataxophragmium rimosum
Volvoshinovella aequigranensis
Cibicidoides (?) voltziana
Neoflabellina reticulata
Reussella szajnochae szajnochae
Globotruncana contusa
Bolivinoides miliaris
Pullenia reussi
Angulogavelinella bettenstaedti
Arenobulimina puschi
Ataxophragmium sp A sp nov.
Abathomphalus mayaroensis
Abathomphalus intermedia
Globotruncana arca
Pyramidina trigonia
Valvulineria lenticula
Osangularia cordieriana
Praebulimina obtusa
Bolivinoides australis
Archaeoglobigerina cretacea
Praebulimina carseyae
Globotruncana linneiana
Globorotalites hiltermanni
Bolivinoides decoratus
Arenobulimina courta
Eponides beisseli
Gavelinella monterelensis
Globotruncana bulloides
Arenobulimina elevata
Neoflabellina rugosa
Bolivinoides laevigatus
Globorotalites micheliniana
Gavelinella lorneiana
Praebulimina reussi
Verneuilina muensteri
Gavelinella clementiana laevigata
Globorotalites conicus
Gavelinella usakensis
Gavelinella clementiana clementiana
Stensioeina exsculpta gracilis
Gavelinella stelligera
Gavelinella thalmanni
Gavelinella cristata
Osangularia whitei
Reussella szajnochae praecursor
Bolivinoides strigillatus
Reussella kelleri
Stensioeina exsculpta exsculpta
Gaudryina laevigata
Verneuilina sp A
Stensioeina granulata polonica
Whiteinella baltica
Praebulimina parva
Neoflabellina praerugosa
Marginotruncana pseudolinneiana
Marginotruncana marginata
Globigerinelloides rowei
Heterohelix reussi
Hedbergella brittonensis
Dicarinella canaliculata
Dicarinella concavata
Stensioeina granulata granulata
Gavelinella cf tourainensis
Lingulogavelinella sp cf L. vombensis
Gavelinella tumida
Neoflabellina baudoniana
Whiteinella aprica
Heterohelix globulosa
Gavelinella tourainensis
Praeglobotruncana stephani
Dicarinella hagni
Lingulogavelinella globosa
Dicarinella algeriana
Praeglobotruncana helvetica
Eggerellina marieo
Hedbergella delrioensis
Gavelinella gp intermedia
Gavelinella baltica
Gavelinella cenomanica
Plectina cenomana
Hedbergella planispira
Praeglobotruncana delrioens
Arenobulimina advena

5000 4940 4910 4730 4610 4520 4460 4400 4050 3960 3330 3180 2980 2910

ZONE	F.I.12	F.I.11	F.I.10	F.I.9	F.I.8	F.I.7	F.I.6	F.I.5	F.I.4	F.I.3	F.I.2	F.I.1		
AGE	EARLY	MID - L-MID	EARLY	LATE		EARLY	LATE	EARLY	MID	LATE	EARLY	LATE	?	
STAGE	CENOMANIAN		TURONIAN		CONIACIAN	SANTONIAN		CAMPANIAN			MAASTRICHTIAN		PALEOCENE	