GEOLOGICAL SOCIETY

QUATERNARY
NEOGENE
PALAEOGENE

Special
Report
No.
9

CRETACEOUS

JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN

by

P. F. Rawson
D. Curry
F. C. Dilley
J. M. Hancock
W. J. Kennedy
J. W. Neale
C. J. Wood
B. C. Worssam

1978

Special Report Series Editor:
PEIGI WALLACE

A CORRELATION OF CRETACEOUS ROCKS IN THE BRITISH ISLES

References to this Report

It is recommended that reference to this report be made in the following form:

RAWSON, P. F., CURRY, D., DILLEY, F. C., HANCOCK, J. M., KENNEDY, W. J., NEALE, J. W., WOOD, C. J. & WORSSAM, B. C. 1978. A correlation of Cretaceous rocks in the British Isles. Geol. Soc. Lond., Special Report No. 9, 70 pp.

из книг
М.С. Месежникова

Misha
with kind regards
Pete

A correlation of Cretaceous rocks in the British Isles

PETER FRANKLIN RAWSON, DENNIS CURRY,
FRANK CHARLES DILLEY, JOHN MICHAEL HANCOCK,
WILLIAM JAMES KENNEDY, JOHN WILLIAM NEALE,
CHRISTOPHER JOHN WOOD &
BERNARD CHARLES WORSSAM

CONTENTS

SUMMARY

The distribution and regional setting of British Cretaceous sediments are summarized. The stratotype sections of the Cretaceous stages used in this report lie in France, the Netherlands, the Soviet Union and Switzerland, and their applicability in Britain is discussed: the definition of the base and the top of the Cretaceous is considered briefly. Two main charts and accompanying text summarize the Lower and Upper Cretaceous correlations across the British Isles and surrounding seas.

---

1. INTRODUCTION

DESIGNATED *terrains crétacés* by d'Omalius d'Halloy in 1822, the System takes its name from *creta*, the Latin for chalk. This is the most conspicuous rock-type in Europe, and Cretaceous chalks are also known from parts of North America and Western Australia. The system is here divided into two and the term 'Middle Cretaceous' is not employed since it has no internationally agreed limits and is little used outside the Middle East. The Lower Cretaceous was formerly separated by some American authors as a distinct system, the Comanchean (from the town of Comanche, Texas). The Upper Cretaceous corresponds roughly to the Chalk Formation of earlier authors. *chalk* (Saxon *cealc*, German *kalk*, meaning lime) having been used as a geological term in England since the Middle Ages and in print from the time of Martin Lister (1684). Its white chalk cliffs gave England its first recorded name of "Albion".

Both the Cretaceous volume of the *Lexique Stratigraphique International* (Hancock, editor, 1972) and the symposium volume *The Boreal Lower Cretaceous* (Casey & Rawson, editors, 1973a) indicate the difficulty of correlating British successions with the standard Cretaceous stages, and the problems are discussed in detail below. In this section there is considerable cross-reference to overseas areas and literature; for this reason and because of the vast regions which would have to be considered, we do not discuss further a correlation with selected foreign sections. Within the British Isles the depositional and structural settings of the Lower and Upper Cretaceous rocks are so different that we discuss their correlation in two separate sections with separate main correlation charts.

During the compilation of this paper there has been an ever-increasing flow of information from continental shelf exploration around Britain, and particularly from the North Sea: much is summarized in the proceedings of a November 1974 conference on 'Petroleum and the Continental Shelf of North West Europe' (Woodland, editor, 1975). We include data available up to March 1976, but are conscious that there is much to come, some of which may profoundly influence the study of the Cretaceous history of Britain. However, it should be emphasized that in North Sea exploration the Cretaceous is not particularly prospective apart from the topmost carbonates (e.g. in the Dan and Ekofisk fields) and coring is therefore at a minimum; information is obtained mainly from cuttings with support from sidewall cores. Drilling generally follows Jurassic highs, and although seismic sections assist in interpretation beyond these, stratigraphical relationships are best known in positive areas and may give a misleading regional impression. The result is that industry has produced a stratigraphical framework which has inevitable limitations for the present purposes.

2. DISTRIBUTION AND REGIONAL SETTING OF BRITISH CRETACEOUS SEDIMENTS

The known outcrops on and around Britain are shown in Fig. 1, together with areas where Cretaceous sediments are known, or assumed, to be concealed. Lower Cretaceous sediments accumulated in several discrete basins (Fig. 2) defined by structures developed during the Jurassic or earlier. Our understanding of the onshore regions has altered radically now that their basins and highs are seen to be lateral extensions of major offshore structures; hence the offshore terminology, though varying in usage from author to author (e.g. *in* Woodland, editor, 1975), is coming into more general use.

On mainland Britain, there were three Lower Cretaceous depositional areas (Fig. 2). North of the Anglo-Brabant Massif, from Norfolk to East Yorkshire (the 'Spilsby' or 'Eastern' Basin), shallow-water sediments accumulated on a stable platform (the East Midlands Shelf of Kent 1975a) limited to the east and north by the Dowsing Fault line and its continuation along the Market Weighton Hinge.

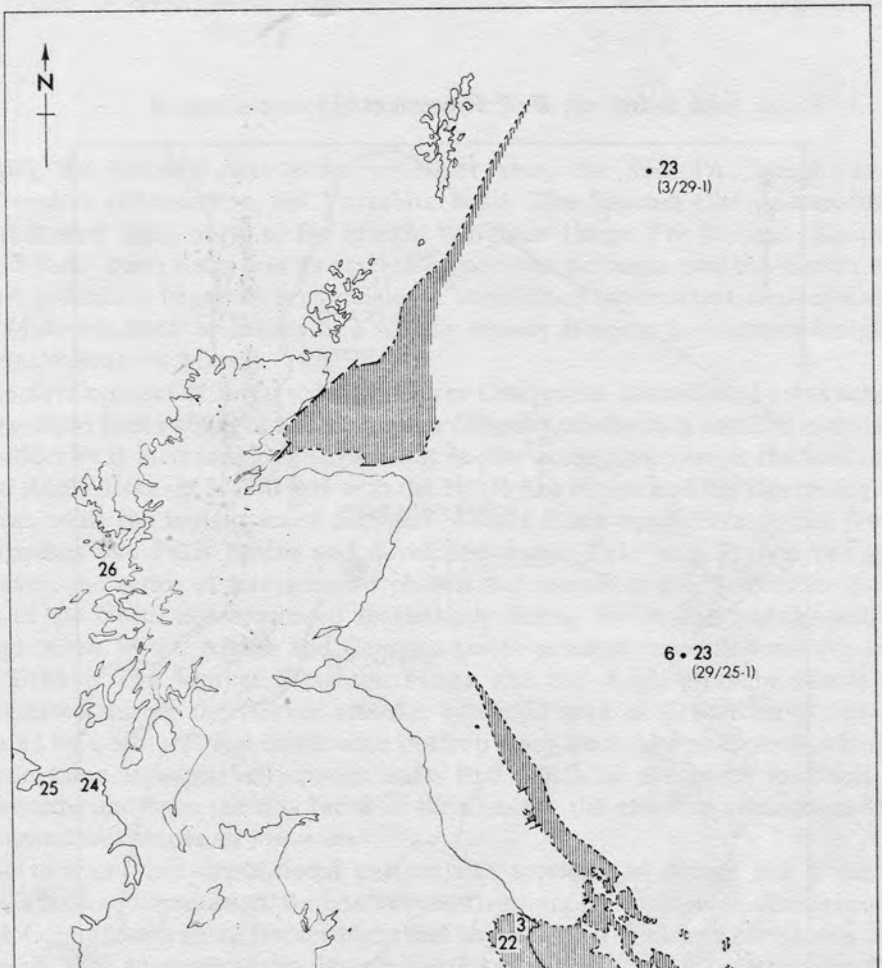


FIG. 1. Distribution of Cretaceous sediments (outcrop and sub-Pleistocene subcrop: indicated by shading) on and around Britain. The numbers indicate the areas included under columns 3–12, 15–26 in the correlation charts (after the J.G.S. map of the Sub-Pleistocene geology of the British Isles and the adjacent continental shelf).

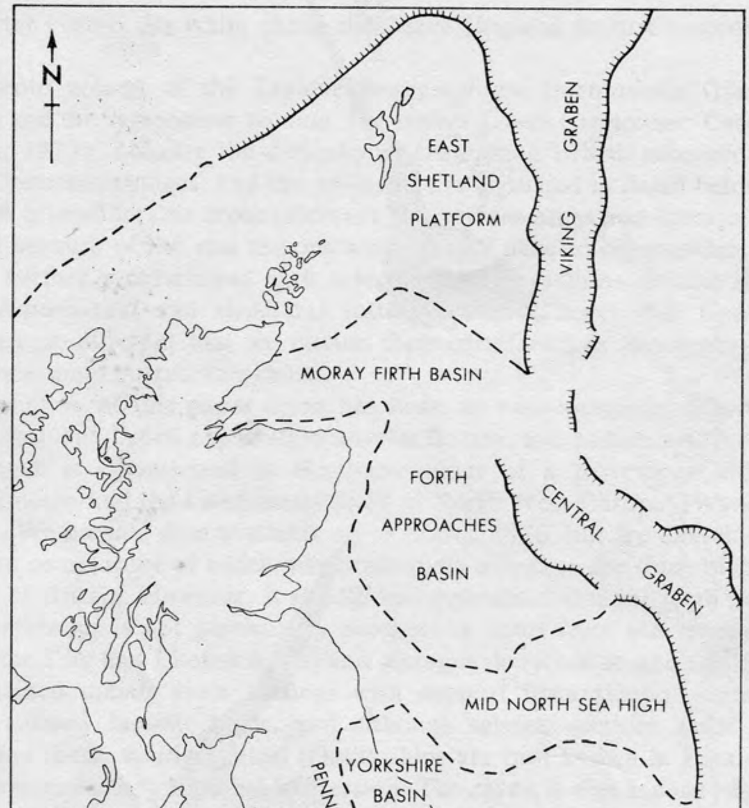


FIG. 2. Structural setting of Cretaceous sediments. N.B. The Sole Pit Trough was inverted during the Cretaceous. M.W.H.—Market Weighton Hinge.

Fringing the platform was a deeper water area, the Sole Pit Trough, and its northwestern continuation, the Yorkshire Basin. The Speeton Clay accumulated in the Yorkshire Basin north of the Market Weighton Hinge. The Wessex ('Southern', 'Anglo-Paris' pars) Basin was an essentially non-marine basin until the Aptian, when marine sediments began to accumulate. It maintained intermittent contact with the East Midlands Shelf by means of a narrow seaway fringing the western margins of the Anglo-Brabant Massif.

The development of three separate Lower Cretaceous depositional areas accounts for the rapid facies changes and hence the difficulty of effecting detailed correlation. The difficulty is increased by the fact that marine communication in the areas north of the Anglo-Brabant Massif was with the North Sea region and the Boreal region in general, while the initially more enclosed Wessex Basin opened out to the Western Approaches and Paris Basins and developed faunal links with France and Spain. However, the series of transgressive phases that started in the Barremian in many parts of the North Sea continued sporadically during the Aptian and reached high enough levels in the Albian and Cenomanian to produce more uniform deposition over Britain. The Market Weighton Hinge and the Anglo-Brabant Massif were transgressed during the Albian and the extended area of deposition is now represented by a more or less continuous outcrop from Yorkshire to Dorset. Along this outcrop there is a marked change from Red Chalk in the north to Gault Clay southwards, and from the clay facies of the Gault in the east into arenaceous Upper Greensand westwards.

The new onshore depositional pattern was accentuated during late Cretaceous times. Chalk sedimentation, initiated in the Cenomanian, continued throughout, the Chalk Formation draping former highs and basins with a thick and continuous cover, although the Anglo-Brabant Massif continued to affect thicknesses and facies. Following the Cenomanian transgressive peak there was a strongly regressive phase during the Turonian, expressed sedimentologically as repeated horizons of nodular chalk and/or hardgrounds, after which there was a second, even more important, transgressive phase which culminated in the late Campanian: during this second phase practically the whole of Britain must have been submerged under a considerable depth of water, with only a few upland areas remaining as islands. In spite of a general fall in sea level during the Maastrichtian, transgressive sediments of this age occur in and around the North Sea.

In the North Sea area, the Cretaceous history was broadly similar. The Mid North Sea High (Fig. 2) and the Ringkøbing-Fyn High separated the northern and southern sectors of the North Sea from late Palaeozoic times onward, but their role diminished progressively during the late Mesozoic until by late Cretaceous times the area developed into a single basin. The Lower Cretaceous depositional pattern continued the earlier history of fault control on a broad scale with local modification of thickness and facies imposed by halokinetic movements, the latter dominating in the southern North Sea. The Upper Cretaceous marks a transition towards the later, Tertiary, basinal subsidence (Kent 1975b), the widespread Chalk facies blanketing earlier irregularities whilst grading northwards into calcareous shales and silts in the

Viking Graben (Howitt 1974; Hancock & Scholle 1975). Some of the former basinal areas, such as the Sole Pit Trough, were inverted during the late Cretaceous.

3. RADIOMETRIC DATES AND THE CRETACEOUS TIME SCALE

Casey (1964) discussed very fully the problems of securing a good radiometric time scale for the Cretaceous, and later work has been reviewed by Lambert (1971). The base of the Cretaceous is dated at 135 ± 5 million years. There are no acceptable dates for the bulk of the Lower Cretaceous, and acceptable Albian figures available from bentonites of the North American western interior (e.g. Williams & Baadsgaard 1975) cannot be related directly to European sequences. For the Upper Cretaceous, work on the bentonites of the same region has been discussed by Obradovich & Cobban (1975), who produced an integrated time scale which can be related to the "standard" Upper Cretaceous ammonite zones used by Arkell *et al.* (1957). Their conclusions are summarized in Table 1 (modified after Kennedy & Cobban 1976). The table demonstrates clearly the disparate duration of Upper Cretaceous stages,

TABLE 1: *Upper Cretaceous time scale.* (all numbers are in millions of years).

Stage	Zone	Duration of zone
64 - 65		
Maastrichtian	*Sphenodiscus sp.* *Pachydiscus neubergicus*	2.5 - 3.0
70 - 71		
Campanian	*Hoplitoplacenticeras vari* *Menabites delawarensis* *Diplacmoceras bidorsatum*	2.7± - 3.0±
82±		
Santonian	*Placenticeras syrtale* *Texanites texanus*	2.0±
86±		
Coniacian	*Parabevahites emscheris* *Barroisiceras haberfellneri*	0.5±
87±		
Turonian	*Subprionocyclus neptuni* *Collignoniceras woollgari* *Mammites nodosoides*	0.67 - 1
89 - 90		
Cenomanian	*Sciponoceras gracile* *Calycoceras naviculare* *Acanthoceras rhotomagense* *Mantelliceras mantelli*	1 - 1.25
94±		

from about a million years for the Coniacian to 11 million years for the Campanian. A somewhat different interpretation of the Cretaceous time-scale is now available (van Hinte 1976).

4. THE LIMITS OF THE CRETACEOUS SYSTEM

(A) *The base of the Cretaceous*

Ammonite provincialism had reached such a peak by the end of the Jurassic that it is extremely difficult to correlate the Tethyan and boreal ammonite sequences near the Jurassic/Cretaceous boundary. Hence a three-fold stage terminology has evolved for the top of the Jurassic: Tithonian for the 'standard' Tethyan sequence and Volgian or Portlandian for the boreal regions. Similarly, alternative stage names have been used for the lowest stage of the Cretaceous: Berriasian, Infravalanginian and Ryazanian. Casey (e.g. 1962, 1973) and Casey & Rawson (1973b) have urged настаивают that the stage name Ryazanian (Sazonov 1951) be used for the basal Cretaceous beds of the Boreal Realm and this is already coming into broader use (e.g. Hancock 1972; Surlyk 1973): adoption of this term for those regions where the underlying Jurassic beds are called Volgian provides a consistency of usage and avoids the избегают confusion caused by the practice (e.g. Saks, editor, 1972) of using a mixed boreal (Volgian) and Tethyan (Berriasian) terminology for the beds spanning the Jurassic/Cretaceous boundary. We regard the Volgian/Ryazanian terminology as a временная мера temporary measure which should be used until correlation is sufficiently advanced for an internationally accepted standard for the base of the Cretaceous to be achieved. It appears likely that the base of the Ryazanian is younger than the base of the Berriasian as currently delimited in France, and that the Berriasian and Volgian stages overlap. The Jurassic/Cretaceous boundary is thus drawn at a higher level in the Boreal Realm than in the Tethyan Realm (e.g. Casey 1963, 1973; Hancock 1972).

Cephalopod faunas of earliest Cretaceous age in the British Isles are boreal, and we therefore follow the *Lexique* (Hancock, editor, 1972) in using Ryazanian as the stage term for the earliest Cretaceous rocks of Britain. Here, the base of the Cretaceous had long been drawn customarily at a phosphatic nodule horizon marking the base of the Speeton Clay Formation (Yorkshire), the Spilsby Sandstone (Lincolnshire) and the Sandringham Sands (Norfolk): everywhere this nodule band rests on Kimmeridge Clay. However, Pavlow (1889) and Casey (1962) recognized Volgian *Craspedites* in the Lower Spilsby Sandstone, and the late Jurassic age of this and of the lower part of the Sandringham Sands is now firmly documented (Casey 1973). The Upper Spilsby Sandstone contains Ryazanian ammonites (Casey 1973) and belemnites (Pinckney & Rawson 1974) whilst the occurrence of *Hectoroceras* provides a firm Ryazanian date for the Mintlyn Beds of the Sandringham Sands (Casey 1961b, 1973). The earliest ammonites of the Speeton Clay (Neale 1962a; Casey 1973) are *Peregrinoceras* and allies of late Ryazanian age: they are preceded by *Acroteuthis* of probable Ryazanian age (Pinckney & Rawson 1974).

In the non-marine Purbeck/Wealden sequence of southern England, the base of the Cretaceous has been drawn at various horizons. The early workers, such as Brongniart (1829), placed it at the base of the Purbeck, while Forbes (1851) and most later authors drew it at the base of the Wealden (which is often difficult to define). Following Casey (1963, 1964), the Cinder Bed horizon in the Purbeck is here taken as the base of the Cretaceous. In Dorset, the beds beneath are termed the Lulworth Beds, while the overlying part of the Middle Purbeck and the Upper Purbeck are termed the Durlston Beds (Casey 1963; Townson 1975 redefines these as Formations). These divisions have not been adopted for the Weald by the Geological Survey because there it is difficult to map the Cinder Bed horizon (Anderson & Bazley 1971), though it can be recognized in boreholes. [illegible]

(B) *The top of the Cretaceous*

Until recently, geologists in Britain gave little attention to the delimitation of the top of the Cretaceous, because wherever the boundary was to be placed it would fall within the considerable gap between our youngest Chalk and our oldest Tertiary. The problem can no longer be ignored as strata straddling the gap are now known in the North Sea and the English Channel.

The problem of the Cretaceous/Paleocene boundary is largely a matter of the placing of the Danian stage. In a number of papers, Hofker (e.g. 1962) correlated the type Danian with the upper part of the type Maastrichtian by foraminifera. This completely contradicts the macrofaunal (belemnite) evidence (*see* Hancock, editor, 1972) and has been refuted by Berggren (1964) who showed that Hofker had misinterpreted many of the foraminifera.

The Danian was made the uppermost stage of the Cretaceous by d'Orbigny (1852) in his *Cours Elémentaire*, apparently as a result of the mistaken idea that it contained *Belemnitella* and *Baculites*. Workers as early as d'Archiac considered the Danian to be Tertiary, but this view was first given strength by de Grossouvre (1897) and is now almost universal (except Orlov 1958; Yanshin 1960; Eames 1968). The top of the Maastrichtian is marked by the final disappearance of the Ammonoidea, the Sauropterygia, the Saurischia, the Ornithischia, and the near disappearance of the Hippuritoida (which include the rudists), the Belemnoidea and the Inoceramidae (Hancock 1967). Important changes in the planktonic foraminiferal faunas occur across the same horizon (Berggren 1962). For these reasons we have excluded the Danian from the Cretaceous system.

5. THE CRETACEOUS STAGES AND ZONES IN BRITAIN

(A) *Introduction*

(i) *The stages*

None of the standard Cretaceous stages has stratotype sections in the British Isles, and some of the stratotypes lie in a different faunal realm. Hence there are problems in interpreting most of the stages in Britain, as detailed below. In general, the British marine Lower Cretaceous is developed in a variety of clastic facies, many of which contain ammonites: as the Lower Cretaceous stages are in effect defined by their ammonite zones correlation can be attempted with some confidence even though some of the 'standard' zones are established on Tethyan faunas. Hence the stage terms have long been familiar in the British literature, though their usage has varied considerably.

The Upper Cretaceous presents greater problems: "Upper Cretaceous" is synonymous with the Chalk over most of the British Isles, though non-chalk marginal facies of Cenomanian age are present in south-west England, Northern Ireland and western Scotland, and in some parts of Northern Ireland the non-Chalk facies extends up to the Campanian.

The classic division of the Chalk has been into Lower, Middle and Upper: the base of the Middle Chalk is marked by the Melbourn Rock (a complex of nodular chalks and incipient hardgrounds) and the base of the Upper Chalk by the Chalk Rock (a composite hardground). Where the Chalk Rock is absent, as in Yorkshire and Lincolnshire, even this lithological division becomes uncertain and perhaps should not be maintained. After the work of Barrois (1876) it was recognized that it was easier to divide the Chalk by its beautiful fossils. In the finer and finer subdivisions that were gradually distinguished, the relations between lithologies and faunas were nearly overlooked. When standard stage names came to be used in Britain, in several cases not until the middle of this century, they were fitted into a pre-existing local zonal scheme. This was ill-defined, and zonal limits were often more influenced by facies than its authors, such as Rowe (1900–1908), had recognized; in several cases stage boundaries have been equated with changes of lithology.

(ii) *The zones*

The zones used in the British Cretaceous have been set up empirically, and used without regard to which theoretical type of zone they may be. In theory most are assemblage zones, including the majority of the Ryazanian to Cenomanian ammonite zones. Some of the ammonite zones are based on an evolutionary lineage, e.g. the *Endemoceras* zones of the Lower Hauterivian; in some cases the range of the index species coincides with the limits of the zone, e.g. *Euhoplites lautus*; in others the index species is not known through the whole of the zone named after it, e.g. *Leymeriella tardefurcata*; in yet others the index species ranges outside its own zone, e.g. *Calycoceras naviculare.*

In the Turonian to Maastrichtian (Middle and Upper Chalk), problems arise from the scarcity or absence of organisms which originally had aragonitic shells, except at certain levels such as the Chalk Rock. For instance, only two ammonites (both texanitids) are known from the Santonian. Yet aptychi occur widely, and the great rarity of ammonites and other aragonitic shells may be the result of sea-floor dissolution. Most Chalk zones are of relatively long duration (1–4ma. y.); some are assemblage zones in which the presence or absence of the index species has little meaning, e.g. Zone of *Terebratulina lata*; others are absolute-range zones, e.g. Zones of *Uintacrinus socialis* and *Marsupites testudinarius*; and a few were intended to be lineage-range zones, e.g. the *Micraster* zones. Some index species may not even occur in the British Isles, e.g. *Micraster cortestudinarium* Goldfuss.

(B) *Lower Cretaceous* (Fig. 3, columns 1, 2)

The Ryazanian

Based on the Ryazan Beds of the River Oka near Ryazan, south-east of Moscow, the stage name (in the form Ryazanskii) was introduced by Sazonov (1951) for the interval between the Upper Volgian below and the Valanginian above. Two ammonite zones were included, that of *Riasanites rjasanensis* below and that of *Surites poreckoensis* (= Zone of *Surites spasskensis* auctt.) above: these were given the symbols $Cr_1^{rjs}1$ and $Cr_1^{rjs}2$ to form part of the standard Soviet stratigraphical nomenclature. The stage name was not adopted by subsequent Soviet workers.

The Ryazan Beds form a condensed, transgressive sequence said to overlie conformably late Volgian sediments with *Craspedites* in places, though their lower contact is commonly disconformable (see Saks, editor, 1972). Equivalent horizons in parts of Siberia are more fully developed and there are some faunal differences between the two regions; for example, *Riasanites* is a southern element which does not appear to have penetrated north of the Russian Platform, being replaced by *Hectoroceras* in more northerly areas. However, there are enough ammonites in common for the Russian Platform and Siberian sequences to be firmly correlated (see Casey & Rawson, editors, 1973a; Casey, Mesezhnikov & Shulgina, in press). The occurrence of *Riasanites rjasanensis* in association with ammonites of the *Fauriella boissieri* fauna in the Crimea and northern Caucasus provides a link with the Tethyan faunas and hence a correlation with the Berriasian Stage. cl. es. 3beho

The English Ryazanian has an extended sequence of ammonite faunas with elements in common with the Russian Platform (e.g. *Peregrinoceras*) and Siberia (e.g. *Bojarkia* and *Hectoroceras*). Forms such as *Surites* are common to all three areas. A five-fold division was proposed and discussed in detail by Casey (1973), as follows:

Upper Ryazanian	*Peregrinoceras albidum* *Surites* (*Bojarkia*) *stenomphalus* *Surites* (*Lynnia*) *icenii*
Lower Ryazanian	*Hectoroceras kochi* *Runctonia runctoni*

The Valanginian

At the type locality (see Haefeli *et al.* 1965) of the Seyon Gorge, near Valangin (Valendis in German), Neuchâtel, Switzerland, the Valanginian stage (proposed by Désor in 1854) is represented by shallow-water deposits with a rich sub-littoral fauna, especially of brachiopods; ammonites are poorly preserved and generally very rare (Barbier & Thieuloy 1965; Donze & Thieuloy 1975). Further south, in the calcareous-argillaceous successions of the Vocontian trough, ammonites are much more common and it is here that Kilian and co-workers established the 'standard' Tethyan zonation, in which the Valanginian was divided into two zones, the *Kilianella roubaudi* Zone below and the *Saynoceras verrucosum* Zone above. Thieuloy (1973) has now proposed a more detailed scheme, as follows:

Upper Valanginian	*Neocomites (Teschenites) callidiscus*
	Himantoceras trinodosum
	Saynoceras verrucosum
Lower Valanginian	*Neocomites campylotoxus*
	Kilianella roubaudi
	Thurmanniceras pertransiens

The Lyons Colloquium (Barbier & Thieuloy 1965; Debelmas & Thieuloy 1965) recommended that a Valanginian parastratotype should be erected, based on a section in the Vocontian trough and preferably in the region of the Hautes-Alpes.

The majority of the ribbed ammonites of Tethys are neocomitids or olcostephanids, whereas the boreal Valanginian (especially in the Soviet Union, eastern England and east Greenland) is characterized by a sequence of *Tollia*-like forms, followed by polyptychitids. In the north German Basin, early Valanginian tolliids are largely replaced by *Platylenticeras*, index genus of the Platylenticeras Schichten (which overlie the non-marine Bückeburg Formation of Casey *et al.* 1975). In south-east France, species of *Platylenticeras* characteristic of the lowest Platylenticeras Schichten occur in the *pertransiens* Zone (Thieuloy 1973), thus providing a firm correlation for the base of the Valanginian. Limited correlation between Germany and France and England and France can be made also at higher levels (Kemper 1973a; Rawson 1973; Thieuloy 1973).

Small, septate specimens of *Paratollia, Propolyptychites, Menjaites* and *Platylenticeras* occur in D4 at Speeton (e.g. Rawson & C. W. & E. V. Wright's collections), and rare *Paratollia, Propolyptychites* and *Pseudogarnieria* in the basal Claxby Ironstone of Lincolnshire. Thus the English early Valanginian faunas provide a link with both the Platylenticeras Schichten of North Germany and the *Pseudogarnieria undulatoplicatilis* Zone at the base of the Valanginian of the Russian Platform.

The higher part of the Valanginian of northern Europe and Arctic regions yields abundant polyptychitids: at Speeton *Polyptychites* appears at the base of Bed D3 and extends to the top of D2E, and the same genus is common in the bulk of the Claxby Ironstone and in the Hundleby Clay. None of the material has been collected in the detail necessary to establish a zonal succession comparable with that of the north German succession, and we recognize therefore only a broad *Polyptychites* Zone. Our Upper Valanginian zonation is a simplified version of the German zonation (*see* Kemper 1973a), in which the unnamed zone at the top corresponds with the Astierien Schichten of earlier authors, for which a satisfactory zonal index has yet to be selected. The Upper Valanginian zones are represented by a remanié horizon at Speeton and by more or less condensed levels in Lincolnshire.

The English Valanginian zonation suggested here is:

Upper Valanginian	unnamed zone (Astierien Schichten fauna)
	Dicostella pitrei
	Dichotomites spp.
Lower Valanginian	*Polyptychites* spp.
	Paratollia spp.

The Hauterivian

The stage was designated by Renévier (1874) for a series of shallow-water deposits at Hauterive, near Neuchâtel, Switzerland. Because of the rarity of ammonites, Debelmas & Thieuloy (1965) recommended that a parastratotype should be erected in the Salerans region (Hautes-Alpes) of the Vocontian trough, south-east France. The Vocontian zonal sequence proposed by Kilian (1907–13) has been modified and expanded by Thieuloy (*in* Moullade & Thieuloy 1967; *see also* Thieuloy 1973) as follows:

Upper Hauterivian	*Pseudothurmannia angulicostata*
	Plesiospitidiscus ligatus
	Subsaynella sayni
Lower Hauterivian	*Lyticoceras nodosoplicatus*
	Olcostephanus jeannoti
	Crioceratites duvali loryi
	Acanthodiscus radiatus

Although there are a few Tethyan ammonites in the English succession (*see* Rawson 1973), little direct correlation can be made between the English and the French sequences. However, in north Germany rare *Acanthodiscus radiatus* and allies occur in the lower part of the Endemoceras Schichten, which are thus regarded as marking the base of the Hauterivian (e.g. Kemper 1973a). At Speeton, the equivalent *Endemoceras* beds rest non-sequentially on the *Polyptychites* beds, the contact marked by a phosphatic nodule bed in which remanié late Valanginian ammonites occur with freshly preserved early Hauterivian forms (Spath 1924; Rawson 1971b). The microfaunal evidence clearly indicates that the stage boundary lies here (Neale 1960b; Fletcher 1973).

The Speeton Hauterivian is divided into two main informal divisions, the *Endemoceras* beds (D2D–C8) and the *Simbirskites* beds (C7–LB5E) and eight ammonite zones (Rawson 1971a, 1971b), as follows:

Upper Hauterivian	*Simbirskites* (*Craspedodiscus*) *variabilis*
	Simbirskites (*Simbirskites*) *marginatus*
	Simbirskites (*Craspedodiscus*) *gottschei*
	Simbirskites (*Milanowskia*) *speetonensis*

Lower Hauterivian	*Simbirskites (Speetoniceras) inversus*
	Endemoceras regale
	Endemoceras noricum
	Endemoceras amblygonium

The Lower/Upper Hauterivian boundary follows Thieuloy's (1973) correlations. The zonation compares closely with the German scheme put forward by Kemper (1973a) and slightly modified by Kemper *et al.* (1974: *see also* Rawson 1974): the *Endemoceras* (= *Lyticoceras* auctt.) zones are based partly on the work of Thiermann (1963).

The Barremian

Barrême and Angles (Basses-Alpes, France) were both mentioned in Coquand's (1861) original designation of the stage, but Busnardo (1965) has now designated the Angles roadside section as the stratotype. This section is almost continuous, completely visible, easily accessible and yields a good ammonite fauna. Busnardo (1965) amended the established zonal scheme but retained a bipartite division into the *Nicklesia pulchella* Zone below and the *Silesites seranonis* Zone above.

Heteromorph ammonites of the family Ancyloceratidae are common in both the French (Tethyan) and north-west European ('boreal') faunas, but faunal similarities between the two areas have been regarded as superficial (e.g. Spath 1924) and taxonomy has diverged accordingly (e.g. Koenen 1902; Sarkar 1955). There is now evidence of elements common to England and south-east France (Rawson 1975a) but at present the poorly known English faunas can be compared only with the north German sequence, where the Barremian is currently divided into zones based on Koenen's and Stolley's work, as follows:

Parancyloceras bidentatum
Hemicrioceras rude
'Crioceras' sparsicostata
Paracrioceras denckmanni
Paracrioceras elegans
Hoplocrioceras fissicostatum
Paracrioceras rarocinctum

In England, Barremian ammonites occur in the Speeton and Snettisham Clays, but only at Speeton is the bulk of the stage represented. Even here exposures are indifferent (*see* p. 31) and the stratigraphical relationships of isolated sections are difficult to establish. Spath's (1924, p. 78) identification of museum specimens suggested that faunas of most of the German zones occur at Speeton, and Spath adopted the German zonation for this sequence. However, the horizon of most specimens is not known and few zonal divisions can actually be established in the field. Most of the crioceratitids occur as flattened calcareous films, and three-dimensional forms are rare and fragmentary. Thus only three zones, one composite, are recognized here:

(a) the *rarocinctum* Zone

First adopted for Speeton by Spath (1924, table) the zone is retained provisionally (Rawson 1971b, p.72) for Beds LB5D–LB4 where large, crushed crioceratitids occur, apparently close to the zonal index.

(b) the *fissicostatum-rude* Zones

Fragments of *Hoplocrioceras* cf. *fissicostatum* (Roemer *sensu* Neumayr & Uhlig) occur in LB3 (Rawson 1971b, p. 72) and other, fragmentary crioceratitids higher in the succession (LB2, LB1 and the Cement Beds). No further subdivision is yet possible.

(c) the *bidentatum* Zone

Parancyloceras bidentatum is common in small exposures of high Upper B, where it occurs with *Toxoceratoides* spp.

The base of the Barremian is provisionally drawn at the base of the *rarocinctum* Zone (Rawson 1971a, p. 80), but this is based in effect on the disappearance of a Hauterivian genus (*Simbirskites*) rather than on the appearance of a well-established Barremian form. Micropalaeontological evidence supports this (Neale 1974) though foraminifera indicate that the boundary could possibly be higher, in Bed LB4C (Fletcher 1973).

The Aptian

The stage was named after the village of Apt (Basses-Alpes) in south-east France, and proposed for strata containing an 'Upper Neocomian' fauna (d'Orbigny 1840). Separation of the classic French Aptian into two substages was formalized by the introduction of the terms 'Bedoulian' (Toucas 1888) and 'Gargasian' (Kilian 1887). To these, Breistroffer (1947) added a third, topmost substage, the 'Clansayesian', for beds previously referred to the Albian by Jacob and others.

In Britain, the Aptian is most extensively developed in the Lower Greensand of southern and eastern England (Fig. 4). A less complete sequence occurs in the top B Beds and lower A Beds of the Speeton Clay. The Aptian was primarily a time of marine transgression, during which the sea returned to southern England after the great Purbeck-Wealden regression. Brackish-water 'Wealden' conditions lingered on into the Aptian in the Swanage to Worbarrow Bay area of Dorset, presumably in the estuary of a Lower Greensand river.

The substages Bedoulian, Gargasian and Clansayesian are not used in Britain, where a simple grouping of zones into Lower and Upper Aptian is employed (Casey 1961a):

Upper Aptian	*Hypacanthoplites jacobi* *Parahoplites nutfieldiensis* *Cheloniceras* (*Epicheloniceras*) *martinioides*
Lower Aptian	*Tropaeum bowerbanki* *Deshayesites deshayesi* *Deshayesites forbesi* *Prodeshayesites fissicostatus*

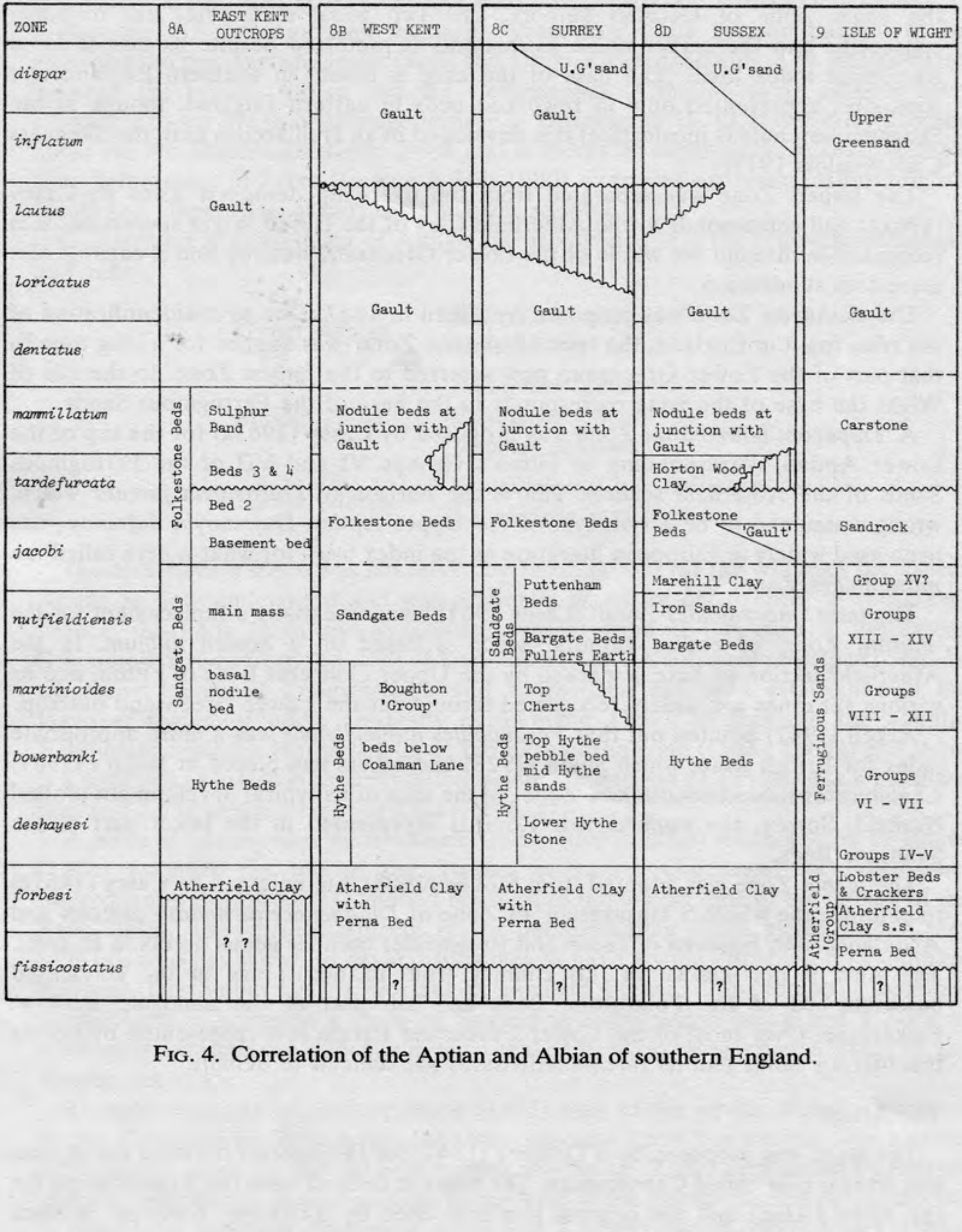


FIG. 4. Correlation of the Aptian and Albian of southern England.

The *fissicostatus* Zone was proposed by Casey (1961a) and corresponds in part to the *bodei* Zone of German authors. The two zonal ammonites are probably conspecific and the earlier name *fissicostatus* is preferred despite its misuse for a Barremian index fossil. The base of the zone is absent in southern England and commonly represented only in reworked beds in eastern England, though in the Skegness borehole (Lincolnshire) it is developed in an argillaceous unit, the Skegness Clay (Gallois 1975b).

The *forbesi* Zone was separated from the overlying *deshayesi* Zone by Casey (1961a) and corresponds to the Atherfield Clay of the Isle of Wight succession. It is recognizable through the whole of the Lower Greensand outcrop and is capable of a three-fold subdivision.

The *deshayesi* Zone was proposed by Kilian in 1887. Due to misidentification of the zone fossil in England, the term '*deshayesi* Zone' was applied for a long time to that part of the Lower Greensand now referred to the *forbesi* Zone. In the Isle of Wight the base of the zone corresponds to the base of the Ferruginous Sands.

A *Tropaeum bowerbanki* Zone was proposed by Casey (1961a) for the top of the Lower Aptian, corresponding to Fitton's Groups VI and VII of the Ferruginous Sands of the Atherfield section. This is the horizon of *Dufrenoyia furcata* which, wrongly assumed to be a synonym of the Upper Aptian *Dufrenoyia dufrenoyi*, has been used widely in European literature as the index fossil for what is here called the *martinioides* Zone.

The term '*martinioides* Zone' (Casey 1961a) was essentially a replacement for the '*martini* Zone' of earlier authors, which is based on a *nomen dubium*. In the Atherfield section its base is marked by the Upper Crioceras Beds of Fitton, and its various subzones are widely recognized throughout the Lower Greensand outcrop.

Arkell (1947) pointed out that *Parahoplites nutfieldiensis* was a more appropriate index for British strata which Spath (1923) and others had placed in Jacob's (1907) *Cheloniceras subnodosocostatum* Zone. In the area of its typical development around Nutfield, Surrey, the *nutfieldiensis* Zone is represented in the lower part of the Sandgate Beds.

The *jacobi* Zone was adopted from Stolley (1908), but enlarged by Casey (1961a) to embrace the whole 'Clansayesian' or Zone of *Diadochoceras nodosocostatum* and *Acanthohoplites bigoureti* of Jacob and Breistroffer (neither genus occurs in Britain). The zone is best-known in this country from its occurrence in the condensed basement-bed of the Folkestone Beds and top part of the Sandgate Beds at Folkestone. Over most of the Lower Greensand terrain it is represented by poorly fossiliferous sands and its three subdivisions are difficult to delimit.

The Albian

The stage was proposed by d'Orbigny (1842) for the interval between the Aptian and what is now called Cenomanian. The name is derived from the Roman name for the Aube (*Alba*) and the original localities cited by d'Orbigny comprise Wissant (Pas-de-Calais), Noires (Haute-Marne), Gaty, Marepaire, Dienville, Ervy (Aube), Saint-Florentin, Perte-du-Rhône (Ain), Mâcheromenil (Ardennes) and Varennes

(Meuse) in France, and Folkestone, Kent, in England. Following Breistroffer (1947), the Albian is regarded as commencing with the *Leymeriella tardefurcata* Zone.

Renevier (1867) introduced the term 'Vraconian' for a horizon thought to be equivalent to the English Upper Gault and Upper Greensand and to be intermediate between the typical Albian and the Cenomanian. Although some authors have allowed it to survive as a substage term (e.g. Drummond 1970), it is merely another name for the *Stoliczkaia dispar* Zone and is therefore superfluous. Jukes-Browne's term Selbornian (*in* Jukes-Browne & Hill 1900), proposed expressly for the English Gault and Upper Greensand, has not been adopted.

In mainland Britain, strata of Albian age are divided into the following substages and zones:

Upper Albian	*Stoliczkaia dispar* *Mortoniceras inflatum*
Middle Albian	*Euhoplites lautus* *Euhoplites loricatus* *Hoplites dentatus*
Lower Albian	*Douvilleiceras mammillatum* *Leymeriella tardefurcata*

The *tardefurcata* Zone was conceived by Jacob (1907) for the whole of the Lower Albian as now understood and was originally based on occurrences in south-east France, the Paris Basin and Switzerland. Recognition of this zone in the Lower Greensand derives from the work of Spath and Casey. A subzonal sequence based on successive faunas of *Proleymeriella* and *Leymeriella* has been established in the Hanover region of north Germany (Brinkmann 1937). In England the hoplitid *Farnhamia* replaces *Proleymeriella* at the base of the zone (Casey 1961a) and there is a widespread break in sedimentation below the horizon of *Leymeriella regularis*—the 'mid-*tardefurcata* break' of Casey (1961a).

A zone of '*Ammonites mammillaris*' (recte *mammillatus*) was taken by de Rance (1868) to mark the top of the 'Aptian or Lower Greensand' of Folkestone. Subsequently Barrois (1874) applied the term to the lowest zone of the Albian of the Paris Basin. The current concept of the *mammillatum* Zone stems from Casey (1961a), who has shown its several subzones to have a wide distribution in southern England. Destombes (1973), working in northern France, drops the term *mammillatum* Zone in favour of a Zone of *Sonneratia dutempleana* below and a Zone of *Otohoplites raulinianus* above but the zonal indices occur in reverse order in the English sequence.

Though originally applied by Jacob (1907) only to the pyritic Middle Albian of Sainte-Croix and the Paris Basin, the term '*dentatus* Zone' has proved to be a useful replacement name for the old '*Ammonites interruptus*' Zone, invalidated by nomenclatorial irregularity. It is ubiquitous at the base of the European Middle Albian and is capable of subzonal division is south-east England (Spath 1941; Casey 1961a; Owen 1971).

The *loricatus* Zone is a comparatively recent concept (Owen 1958) and consists essentially of the lower part of the zone of *Ammonites lautus* as used by Jukes-Browne, being typified by beds II–IV and the basal part of bed V of the Folkestone Gault, each of these beds representing a different subzone.

The recognition of a *Euhoplites lautus* Zone has its origins in Price's (1874, 1875) use of the term 'Zone of *A. lautus*' for his bed V of the Folkestone Gault. It was subsequently extended by Jukes-Browne & Hill (1900) to embrace beds II–VII of Price's classification and modified by Spath (1941) to take in beds IV–VIII. Current usage confines it to most of bed V together with beds VI and VII.

The 'zone of *Ammonites inflatus*' was used by de Lapparent (1868) when correlating occurrences in France, but without palaeontological definition. Subsequent usages by Barrois (1874) and Jacob (1907) refer properly to the *dispar* Zone ('Vraconian'). The present-day connotation of the *Mortoniceras inflatum* Zone dates from Spath (1923). This zone and its various subzones is widespread in the Gault of England. It corresponds roughly to the old 'zone of *Ammonites rostratus*', but *Mortoniceras rostratum* s.s. is absent from the *inflatum* Zone *sensu* Owen (1976).

The *Stoliczkaia dispar* Zone was introduced by Spath (1923) and replaced such inappropriate terms as 'Zone of *Pecten asper*' and 'Zone of *Mortoniceras inflatum*' for the highest Albian. The zone is widespread in England, but the subzonal divisions employed by Spath are not easy to recognize. However, Owen (1976) distinguishes a subzone of *Mortoniceras rostratum* which he includes within the *dispar* Zone.

(C) *Upper Cretaceous* (Fig. 6, columns 13, 14)

The Cenomanian

The Cenomanian stage was introduced by d'Orbigny (1847, 1850, 1852) with the environs of Le Mans (Cenomanum) in the Sarthe, France, as the type locality. Sornay (1957) reviewed the history of the various usages of the term, whilst Hancock (1959) listed the ammonite faunas of the type area and other localities in the Sarthe. The microfauna has been described partially by Marks (1967) and Hart (1971).

The base of the stage has usually been taken at the base of the Argile Glauconieuse à Minerai de Fer (Guillier 1886; Delaunay 1934; Sornay 1957; Hancock 1959; Juignet 1968), which rests unconformably on Oxfordian clays. There have been no exposures of the Argile Glauconieuse à Minerai de Fer in Le Mans itself for many years, but macrofaunas from the same formation west and north-west of Le Mans (Juignet & Kennedy, unpublished) and the records of Hancock (1959) demonstrate that faunally the base of the stage is best taken at the base of the beds with the *Hypoturrilites carcitanensis* assemblage at the bottom of the Zone of *Mantelliceras mantelli* as used in England by Kennedy (1969, 1970, 1971) and Kennedy & Hancock (1971).

The Cenomanian ammonite zones used here are:

Upper Cenomanian	*Sciponoceras gracile* *Calycoceras naviculare/Eucalycoceras pentagonum*
Middle Cenomanian	*Acanthoceras rhotomagense*
Lower Cenomanian	*Mantelliceras mantelli*

The *mantelli* and *rhotomagense* Zones have been subdivided by Kennedy (1969, 1970, 1971); the subdivisions have been recognized in Normandy and Maine (Kennedy & Hancock 1971; Juignet 1973; Juignet & Kennedy 1977) and west Germany (Hancock, Kennedy & Klaumann 1972), and may be traceable into Africa (Kennedy & Hancock 1971; Cooper 1972, 1973, 1974). Like many other smaller divisions, they have not been used in the main correlation chart because they cannot all be recognized in Scotland, Ireland, or England north of the Chilterns, due to the scarcity of ammonites in these regions.

The Upper Cenomanian is still given different meanings by different geologists, chiefly because of disagreement on the placing of the Cenomanian/Turonian boundary (discussions in Schmid 1965; Kennedy & Juignet 1973; Berthou & Lauverjat 1974). We have followed recent usage (e.g. Tröger 1967, 1968; Hancock 1969; Kennedy & Juignet 1973; Juignet, Kennedy & Wright 1973) and put the base of the Turonian at the base of a broad Zone of *Mammites nodosoides* (see Turonian stage below). This leaves within the Cenomanian the obsolete Zone of *Actinocamax plenus* and an unnamed subzone in the bottom part of the overlying Melbourn Rock called Horizon A by Juignet *et al.* (1973).

The subdivision of the Upper Cenomanian is in a state of flux. We recognize that there is an objection to the retention of *C. naviculare* as an index-name for the lower zone in that it is now known that the lectotype came from the Plenus Marls in the *S. gracile* Zone, and the species may be more common in that zone, but the name for the lower zone is well established and the index species is geographically widespread within the zone. *Eucalycoceras pentagonum* has been suggested as a substitute (Juignet & Kennedy 1977); this species is a rarity and is found only in the upper part of the zone, but it is geographically widespread.

The Zone of *Sciponoceras gracile* is already well known in the western interior of North America (Cobban & Scott 1972) and we now extend its usage to this country. It embraces the former Zone of *Actinocamax plenus* (which was almost a biostratigraphical synonym of the lithic Plenus Marls) and Horizon A of Juignet *et al.* (1973). The *gourdoni* Zone of Jefferies (1962) and Horizon A Zone of Juignet *et al.* (1973) certainly fall into this zone in the American sense, and the *geslinianum* Zone of Jefferies (1962) may also. Part of the complication here is that whilst Jefferies (1962, 1963) was able to subdivide the Plenus Marls into two subzones on the non-ammonite macrofauna, he named these divisions after two ammonites, *Metoicoceras geslinianum* (d'Orbigny) and *M. gourdoni* (de Grossouvre), which we now believe to be conspecific.

The Turonian

The Turonian stage was introduced by d'Orbigny in 1842, but in 1847 he made the lower part of this the Cenomanian stage, and thus limited the Turonian to the upper part of his original stage. He listed fossils from the Turonian in 1850, and in 1852 designated the type area as lying between Saumur (on the river Loire) and Montrichard (on the river Cher). This geographical limitation of the type area has been ignored by most subsequent geologists. In 1959 Lecointre, in a paper specifically on the type Turonian, laid emphasis on the Cher valley as far east as Fretevou, which has led Butt (1966) and Bellier (1971) to refer to the Cher valley as the type area, and to include sections outside d'Orbigny's definition. To confuse matters further, many geologists have placed two units—the Sables de Bousse and the Craie à *Terebratella carantonensis*—within the basal part of the Turonian (e.g. Triger 1869; Guillier 1886; Delaunay 1934; Lecointre 1959 but not 1947 and 1957). The Sables de Bousse does not occur in Touraine; the Craie à *Terebratella carantonensis* (which as originally defined by Triger in 1869 included the Sables de Bousse) is a name for the basement bed of the Chalk used locally in the Sarthe, where it is sometimes rich in brachiopods: no such brachiopod-rich basement bed to the Chalk has been recorded from Touraine.

The lowest formation of the type Turonian that falls within the definitions of d'Orbigny and as mapped by Alcaydé (1968, 1970, 1971), is the Craie Marneuse. Amongst the few ammonites recorded from this are *Mammites nodosoides* and *Lewesiceras peramplum* auct. (Lecointre 1947), but more common is *Inoceramus labiatus.* These fossils show that the formation falls into the widely used Zone of *Inoceramus labiatus,* whose base is known to coincide elsewhere with the base of the Zone of *Mammites nodosoides* (Kennedy & Juignet 1973; Juignet *et al.* 1973). This definition for the base of the Turonian not only conforms with the type area, but is a horizon which can be recognized over much of the world. However, at Fretevou the base of the Craie Marneuse yields *gracile* Zone ammonites, suggesting that here at least, it spans the stage boundary. This supports recent work on the foraminifera of the Turonian of Touraine, most of which has been based on sections which lie outside the type area (Butt 1966; Bellier 1971). However, the Craie Marneuse at Fretevou, only 22 km east of Montrichard, has yielded, amongst a variety of species, *Praeglobotruncana* cf. *hagni* (*see* Butt 1966) and *P. imbricata* (*see* Bellier 1971). Such twin-keeled globotruncanids are known worldwide to begin their range during the upper part of the range of *Rotalipora,* and Jefferies (1962) has shown that this overlap takes place in Britain within the Plenus Marls (*Sciponoceras gracile* Zone, Upper Cenomanian). The lower limit of this interval of overlap is apparently as low as the *naviculare* Zone as dated by Thomel in the south of France (Porthault, personal communication), and the upper limit of *Rotalipora* is not yet known in the type area of the Turonian. In Sarthe, *Rotalipora* has not been recorded above the *rhotomagense* Zone (Marks 1967) in the Cenomanian. A precise interpretation of the Cenomanian/Turonian boundary in terms of the globotruncanid sequence is therefore yet to be achieved and the perennial question of the occurrence of *Rotalipora* in the Turonian yet to be settled.

It is unfortunate that *Globotruncana helvetica*, widely regarded as an index form for the Turonian in Tethyan regions (*see* Moorkens 1969), has not been found in Touraine, although Porthault (personal communciation) has found this species as low as the 'Zone à *Metoicoceras geslinianum*' of southern France (= Zone of *Sciponoceras gracile* herein).

In Britain, the base of the Turonian has been drawn at:

(a) the base of the Zone of *Sciponoceras gracile* as understood here (Spath 1926; Wright & Wright 1951; Jefferies 1962, 1963; current practice of the Institute of Geological Sciences), although the Zone of *Actinocamax plenus* has been included by some authors (e.g. Jefferies 1962) within their Zone of *Inoceramus labiatus.*

(b) Between beds 4 and 5 of Jefferies (1962) within the Plenus Marls which corresponds with the disappearance of *Rotalipora cushmani*; this horizon falls within the obsolete Subzone of *M. gourdoni* (Wood 1965; Hart *in* Stinton 1971).

(c) the base of the Middle Chalk (= the base of the Melbourn Rock) (Jukes-Browne & Hill 1903).

In accordance with the international standard explained above, the base of the Turonian should be placed at the base of the *Mammites nodosoides* assemblage Zone: *M. nodosoides* itself appears within the Melbourn Rock, 2–3 m above the Plenus Marls in Kent and Sussex, and is known from Devon to Norfolk.

No satisfactory macrofaunal subdivision and correlation of the English Turonian is applicable at present. Ammonites are too scarce for general use, whilst detailed inoceramid biostratigraphy (Kauffman, in press) has been applied to only a few British sections. We have therefore been forced to apply, with slight modification, the classic zones used by Rowe (1900–1908), Jukes-Browne & Hill (1903, 1904), and the Institute of Geological Sciences in their numerous sheet memoirs. These are relatively broad divisions when compared with the ammonite subzones applied to earlier parts of the Cretaceous (see p. 9). Moreover, the limits of these zones are ill-defined and therefore hard to apply with consistency in the field.

The assemblage zones are as follows; no precise correlation is intended between the two columns:

British Chalk Zones	International Ammonite Zones
Holaster planus	*Subprionocyclus neptuni*
Terebratulina lata	*Collignoniceras woollgari*
Inoceramus labiatus	*Mammites nodosoides*

An approximate correlation of these zones with those in northern France can be made because they are themselves based on zones established there by Hébert and Barrois. Correlation with internationally known ammonite zones is still little advanced on that tabulated by Hancock (1972, p. 146; see above), based on the records by Wright & Wright (1951). The four-fold division of the type Turonian put forward by de Grossouvre (1901, pp. 779–781) was based largely on species of *Romaniceras*, a genus of extreme rarity in Britain.

The Zone of *Inoceramus labiatus* contains *Mammites nodosoides* and *Lewesiceras peramplum* in the basal part. Echinoids from this zone in Devon recorded as *Micraster leskei* (e.g. Rowe 1903) are now believed to be *Epiaster* (Stokes 1975, p. 33).

The Zone of *Terebratulina lata* contains *Collignoniceras woollgari* (Wright & Wright 1951); *Scaphites geinitzii* in the zone in Norfolk (Peake & Hancock 1961); *Lewesiceras* cf. *mantelli* and *Hyphantoceras* 24 m below the *planus* Zone in Kent (Holmes *in* Dines *et al.* 1969, p. 106). Further records depend on the definition of the boundary between the *lata* and *planus* Zones, but as normally used the top part of the *lata* Zone also yields *Scaphites geinitzii, Sciponoceras bohemicum* (Melville *in* Smart *et al.* 1966), and *Subprionocyclus neptuni.* It is probable that in the future the most reliable marker for the base of the zone will be the appearance of *Inoceramus cuvieri* (E. G. Kauffman, personal communication). *Micraster* from this zone are a small form of *M. corbovis* (Stokes 1975).

The base of the Zone of *Holaster planus* is taken to coincide with the base of the Chalk Rock where that occurs, that is approximately from Wiltshire to Norfolk. In some places this formation contains a rich ammonite fauna: *Scaphites geinitzii, Otoscaphites bladenensis, Metaptychoceras smithi, Allocrioceras woodsi, Sciponoceras bohemicum, Bostrychoceras woodsi, Hyphantoceras reussianum, Austiniceras? curvatisulcatum, Lewesiceras mantelli, Subprionocyclus neptuni, S. hitchinensis, S. branneri* (Wright & Wright 1951; Wood *in* Worssam & Taylor 1969). Some revision of these names will appear in Wright (in press).

There is a single specimen of *Romaniceras deverianum* from a level close to the Chalk Rock from the Latimer area of Buckinghamshire (C. W. Wright colln); it is important to note that de Grossouvre's index for his top zone of the Turonian occurs around this horizon.

The characteristic *Inoceramus* of the *planus* Zone is *I. costellatus.* There are two common species of *Micraster*: *M. leskei* and, less commonly, a large form of *M. corbovis. Echinocorys* are rare in the *lata* Zone except locally in East Anglia, but in the *planus* Zone of southern England *E. gravesi* is quite common.

There is no published account of British Turonian microfaunal sequences as such, although there are scattered references to individual occurrences of Turonian index foraminifera. Carter (*in* Bruckshaw *et al.* 1961) figured but did not name a form which appears to be *Globotruncana helvetica* from the Middle Chalk of south-east England, above the Melbourn Rock. Curry, Murray & Whittard (1965) referred to *Globotruncana sigali* and *G. coronata* in a sample off the Scilly Isles. To judge from confidential oil company records and the work of Moorkens (1969) in Belgium, the rather general occurrence of *G. helvetica* may be expected in southern England, and it is known from above the Black Band in Yorkshire and north Lincolnshire.

The Senonian stages

The Senonian is taken conventionally to embrace the Coniacian, Santonian and Campanian stages, whose stratotypes are in central France in the Aquitaine Basin.

Their development includes both clastic and carbonate facies, probably warm-water, with ammonites and rudistids and orbitoid foraminifera in the upper part. These faunas can provide nearly world-wide correlation, although there is disagreement on where the boundaries should be placed even within the Aquitaine Basin (see Séronie-Vivien 1959, 1972; van Hinte 1965; van Gorsel 1973). In northern Europe none of these groups is common enough to make correlation with the stratotypes easy (see discussion of individual stages below).

In France north of the Aquitaine Basin, in England and eastwards across northern Europe, most of the Senonian is developed as white-chalk (craie blanche, schreibkreide), with few ammonites, virtually no rudists, and no orbitoid foraminifera. This northern region is itself approximately divided into two faunal subprovinces:

(1) A southern subprovince, which includes the Chalk of the Wessex–Paris Basin. The macrofauna is dominated by echinoderms, with subordinate bivalves (including *Inoceramus*) and brachiopods; ammonites are generally very rare, belemnites moderately common only at the top. Smaller foraminifera are common enough, but there is remarkably little stratigraphical work published on them (e.g. Williams–Mitchell 1948; Barr 1962), and this has been fitted into the existing macrofaunal zones. Thus there is a general acceptance of a zonation largely based on echinoderms below and belemnites above which was originally worked out by Hébert (1863 onwards) in northern France, brought to England by Barrois (1876), and extended by Jukes-Browne, Rowe, Griffith & Brydone and Gaster (see Fig. 6).

(2) A northern subprovince in Yorkshire and Lincolnshire (occasionally reaching south into north Norfolk) and extending across the North Sea to Denmark, through Germany and Poland, and then south-eastwards to the northern slopes of the Caucasus in the Soviet Union. The macrofauna contains fewer echinoderms (and those that are common to the two subprovinces are in different proportions), but more belemnites, inoceramids and porifera, and even a few ammonites. The geographically northern Chalk of Northern Ireland contains many belemnites and occasional ammonites, but scarcity of inoceramids together with a relative abundance of echinoids would mark it as part of the southern subprovince.

There are some difficulties of correlation between these two subprovinces, and different zonal schemes have been worked out for Yorkshire and southern England (*see* Wright & Wright 1942; Peake & Hancock 1961; Reid 1973, 1976; Wood *in* Smart & Wood 1976). In the Campanian there is a common belemnite zonation, and the *Marsupites* and *Uintacrinus* Zones of the Santonian are recognizable in both subprovinces. For the Lower Santonian and Coniacian it seems likely that in time a single inoceramid zonation based on that worked out in the Germanies and North America will be found applicable to both subprovinces (Seitz 1956; Tröger & Haller 1966; Kauffman 1975). Similarly, the zonation based on *Bolivinoides* worked out in West Germany probably spans both subprovinces (Hiltermann 1963 and Table 2).

TABLE 2: *International globotruncanid zonal scheme.*

GLOBOTRUNCANID ZONES TETHYAN	GLOBOTRUNCANID ZONES N. EUROPE	N.W. GERMAN *BOLIVINOIDES* ZONES[1]	GERMAN STAGES		BRITISH ZONES	FRENCH STAGES sensu De Grossouvre[2]	CONVENTIONAL AMMONITE ZONES[3]
*mayaroensis**		*draco draco**	Maastricht	O	(absent onshore)	Campanien Supérieur	*Sphenodiscus sp*
*contusa**		*paleocenicus/ peterssoni**		U	*B. occidentalis*		*P. neubergicus*,
calciformis	Zone of 'twin-keeled' *Globotruncana:- arca*, cretacea*, parvaventricosa.*	*draco miliaris**			*B. lanceolata*		
calcarata			Campan	O	*B. mucronata*	? Campanien Inférieur	*H. vari*
stuartiformis		*decoratus** *hiltermanni**		U	*G. quadrata*		*M. delawarensis*
		*strigillatus**			*O. pilula*		*D. bidorsatum*
elevata			Santon		*M. testudinarius*	Santonien	*P. syrtale*
					U. socialis		*T. texanus*
*concavata**					*M. coranguinum*	Coniacien	*P. emscheris*
sigali/renzi*			Coniac		*M. cortestudinarium*		*B. haberfellneri*
*helvetica**			Turon		*H. planus*	Turonien	*S. neptuni*
					T. lata		*C. woollgari*
					I. labiatus		*M. nodosoides*

* recorded from the British region.

[1] after Hiltermann and Koch

[2] based on de Grossouvre (1901) who did not use the term Maastrichtian. His boundary between Campanien supérieur and Campanien inférieur is now difficult to interpret (see Sornay 1957, p. 214), but there are indications that it may have been slightly lower, within the *mucronata* Zone. Most modern French geologists use Maastrichtian as a stage name in the same sense as the German Maastricht.

[3] There is some discussion of these zones and their possible British equivalents in the text, pp. 21–29.

Unhappily the inoceramid zones in Germany have been assigned to stages bearing standard names but with different boundaries from those used elsewhere in the world. In order to compare the German inoceramid zonation with that of the British Chalk, and put our zones into stages as universally used outside central Europe, it is first necessary to correlate the inoceramid zones with the world standard ammonite zonation. This has been done by drawing on evidence from a variety of regions where both ammonites and inoceramids occur together (Kauffman 1975), and by other indirect means.

The international globotruncanid zonation (Table 2) is difficult to apply even to the Aquitaine Basin because many of the zonal indices were limited to more southern climates. Thus *Globotruncana calcarata* has not been recorded north of approximately the front of the Alps, whilst others such as *G. concavata* and the single keeled forms of the *G. stuarti* group are of such rare occurrence beyond Tethyan waters as to be almost valueless for correlation in northern Europe.

The Coniacian

The term Coniacian was introduced by Coquand (1857) with the town of Cognac (Charente) in the northern part of the Aquitaine Basin as the type locality. The stage in Aquitaine was described in some detail by Arnaud (particularly in 1877), but was then largely neglected until 1956 when Séronie-Vivien started to restudy the type area and its fauna.

Base of the Coniacian

The basal glauconitic sands at Cognac, which rest unconformably on Turonian hippuritid limestones, contain no fossils of correlative value (Séronie-Vivien 1972, p. 30). However, the base of the Coniacian must coincide with the base of the Senonian, and the standard formation usually taken as the base of the Senonian is the Craie de Villedieu of Touraine (Sornay 1957). The bottom member of this formation (Zone A of de Grossouvre) contains ammonites which, according to de Grossouvre (1895–1901, p. 348), include: *Barroisiceras haberfellneri*, *Peroniceras tricarinatum*, *Paratexanites zeilleri*, *Gauthiericeras margae* (sometimes quoted as Upper Coniacian), *Tissotia* (*Metatissotia*) *ewaldi*, *Proplacenticeras fritschi*, and *Scaphites meslei*. It is this assemblage therefore that characterizes the Lower Coniacian, the Zone of *Barroisiceras haberfellneri*. Thus the base of the Coniacian is marked by the appearance of *Tissotia*, *Barroisiceras*, and early texanitids such as *Peroniceras*.

In the virtual absence of ammonites in England at these horizons, direct correlation with the stratotype base of the Senonian is dependent on other groups, and there is no modern work on these from the Craie de Villedieu. De Grossouvre (1895–1901) recorded *Micraster decipiens* from various levels in the Craie de Villedieu, and believed it a species characteristic of the Coniacian. The English *Micraster cortestudinarium* Zone contains *M. decipiens* throughout (= *M. cortestudinarium sensu auct. angl.*, ? *non* Goldfuss), and it is largely on this basis that in England the base of the Coniacian has been placed at the base of the *cortestudinarium* Zone. In the bottom few metres of the zone in Normandy and southern England *M. decipiens* is less common than *M. normanniae,* a species which appears within the top of the underlying Zone of *Holaster planus* (Stokes 1975). On this basis, Stokes has subdivided the *cortestudinarium* Zone into two: a thin Zone of *M. normanniae* below and a much thicker zone of *M. decipiens* above. He considers the *normanniae* Zone to be Turonian and only the *decipiens* Zone to be Coniacian. Whilst it is quite possible that the Turonian-Coniacian boundary, corresponding to the base of the Craie de Villedieu, lies above the base of the English *cortestudinarium* Zone, there is no evidence that it coincides with the junction of Stoke's *normanniae* and *decipiens* Zones. We have therefore left the stage-boundary on our correlation table at the base of the *cortestudinarium* Zone.

Further extrapolations can be made using evidence from areas where inoceramids occur in association with Coniacian ammonites. Unfortunately, direct correlation of the classic German inoceramid succession with either of the French stratotypes is impossible at present, both because of lack of work on the French inoceramids and because stratigraphical details of the many Coniacian ammonites recorded from Germany (e.g. Schlüter 1871–6) are mostly lacking (Schmid 1956). Of critical importance, however, is the recent discovery (E. Seibertz, personal communication) of the diagnostic Coniacian ammonites *Barroisiceras* cf. *haberfellneri* and *Scaphites geinitzii intermedius* in the supposedly Upper Turonian (Ober-Turon) Schloenbachi Schichten near Anröchte, West Germany. The horizon is in the *Inoceramus deformis* Zone *sensu germanico* and yields *I. schloenbachi* Böhm which indicates a correlation with the upper part of the English *cortestudinarium* Zone.

In the United States and the Caribbean the lowest Coniacian ammonites such as *Peroniceras, Forresteria* and *Barroisiceras* coincide with the appearance of *Inoceramus rotundatus* which is itself the start of a lineage through *I. erectus* and *I. deformis* up to *I. schloenbachi* of the Upper Coniacian (Kauffman 1975 and in press). With the exception of *I. schloenbachi,* none of the species of this lineage have yet been found in England or in the Craie de Villedieu, but this American evidence strongly supports correlating the *I. rotundatus* horizon with the base of the type Coniacian and further substantiates the assignment of the Schloenbachi Schichten and the upper part of the English *cortestudinarium* Zone to part of the *haberfellneri* Zone. The most that can be said at present from the limited *Inoceramus* material of known horizon is that the base of the Coniacian lies some way below this.

It should be noted that the base of the Coniac Stufe in Germany is drawn at the incoming of the inoceramids of the group of *I. koeneni* and *I. involutus,* which corresponds with the base of the *coranguinum* Zone.

The different meaning given to Coniacian in Germany, where much work on the microfaunas has been done, makes it difficult to define the Turonian-Coniacian boundary on foraminifera. In southern England the base of the *cortestudinarium* Zone is marked approximately by the incoming of *Reussella cushmani* (Williams-Mitchell 1948). In Devon the base of the Coniacian is marked by the replacement of the Turonian *Globotruncana pseudolinneiana* by the inflated form of *G. bulloides* (Bailey 1975).

Subdivision of the Coniacian stage

Following de Grossouvre (1895–1901) the Coniacian is divided into two ammonite zones:

Paratexanites emscheris
Barroisiceras haberfellneri

At present, it is difficult to fit these into the British succession (see above). Divisions based on *Micraster* have been recognised in southern England (*see* Peake *in* Hancock, editor, 1972; Stokes 1975).

The Santonian

Coquand (1857) named this stage after the village of Saintes in the Charente valley (Charente Maritime), but in the course of several papers he mentioned a variety of sections in 'soft chalk with flints', not only around Saintes but also in the valley of the Dronne (Charente). The sequence comprises yellowish-white marly chalks, bryozoan-rich chalks and limestones with flints, with hardgrounds and oyster-beds at some levels. The macrofauna is rich and varied, but generally poorly preserved; the microfauna is richer than that of the type Coniacian, but it is depleted in planktonic elements, and arenaceous forms predominate. At the present time it is not possible to determine the faunal base of the stage in the stratotype area, nor can its upper limit be established. Séronie-Vivien (1972) considers that the base of the Santonian is marked by the appearance of a distinctive *Daviesina*, and *Globotruncana* cf. *bulloides* and *G. lapparenti lapparenti* occur some 11 m above the base at Javrezac (Séronie-Vivien 1972, p. 32).

Based on the Santonian succession in the Corbières (Aude), de Grossouvre (1895–1901) recognised two ammonite zones:

Placenticeras syrtale
Texanites texanus

Both zonal indices have been found in the immediate vicinity of Saintes (Séronie-Vivien 1972, p. 136).

De Grossouvre (1895–1901) equated the Santonian stage with the upper part of the Craie (Zone) *à Micraster coranguinum* and the Craie (Zone) à *Marsupites* of the Paris Basin. Using non-ammonite elements of the faunas, it can be established that the Aquitanian Santonian can be correlated with the Santonian portion of the Craie de Villedieu in Touraine, which itself is in part the lateral equivalent of the *Marsupites* Zone (here presumed to include the equivalent of the English *Uintacrinus socialis* Zone) of the northern part of the Paris Basin. Following this correlation of de Grossouvre, English geologists regard the *Marsupites* Zone as Santonian, and take the base of the succeeding Campanian stage at the base of the overlying *Offaster pilula* Zone.

The zones currently used in England are:

Marsupites testudinarius
Uintacrinus socialis
Micraster coranguinum (pars)

Two Santonian texanitids have been collected from one pit in Kent from the upper part of the *coranguinum* Zone. The base of the Santonian in England is therefore probably some way above the base of the conventional *coranguinum* Zone. The only ammonites known from the *socialis* and *testudinarius* Zones are giant *Parapuzosia* which do not improve the correlation.

In Kent, typical Santonian undulatoplicate inoceramids come in a few metres beneath Bedwell's Columnar (flint) Band (approximately 20 m below the *Uintacrinus* Zone) which itself contains *Inoceramus cardissoides* and a maximum abundance of *I. undulatoplicatus*. This would correspond with the base of the Santon-Stufe as used in central Europe, but the true base of the Santonian may well be lower in the *coranguinum* Zone. Unhappily the only *Inoceramus* known from the Santonian (upper) of Saintes is *I. goldfussi*, a species that is probably endemic to Aquitaine (Sornay 1959).

Micraster is commonly used in England to fix the horizon within the *coranguinum* Zone, in spite of its relative scarcity in the middle part of the zone, but there are no species in common with the Aquitaine basin (Stokes 1975). *Echinocorys* may well prove a more valuable echinoid for correlation (*see* Peake *in* Hancock, editor, 1972).

The foraminifera of the Aquitaine Santonian have been listed by Séronie-Vivien (1972), who found that it was not possible to subdivide the stage with them; nor did she record *Globotruncana concavata* which is widely regarded as the prime index for the Santonian. Barr (1962) recorded this species from the *cortestudinarium* and *coranguinum* Zones of the Isle of Wight: his figured specimen was from a high level in the *coranguinum* Zone, and we suspect that his examples from the *cortestudinarium* Zone may be a different species. The genus *Bolivinoides* begins its range within the Santonian (Table 2) and its earliest representative, *B. strigillata*, was first described from the Taplow Phosphatic Chalk, probably from the *testudinarius* Zone (Barr 1966; Barr & Cordey 1964).

The Campanian

The stage name Campanian was introduced by Coquand in 1857 on the basis of sections he had described in 1856, one of which, the hillside at Aubeterre-sur-Dronne (La Grand Champagne) in Charente, he effectively designated as the type in 1858. According to Coquand, the Campanian is the soft chalk with *Ostrea vesicularis* (his zones G to C in ascending order), the overlying beds being referred by Coquand to his Dordonian stage. Subsequently, Arnaud (1877) modified the original concept of both stages, drawing the base of the Dordonian at the point of entry of the large foraminifer *Orbitoides media* at the base of Coquand's Zone F, and recorded a succession of ammonite assemblages from various localities in the Aquitaine Basin. It was Arnaud's interpretation of these two stages which was later used by de Grossouvre (1895–1901, pp. 377, 801) to work out possible zonations of the Campanian stage, from which the present standard quadripartite division has been formulated:

Bostrychoceras polyplocum
Hoplitoplacenticeras vari
Menabites (*Delawarella*) *delawarensis*
Diplacmoceras bidorsatum

The base of the stage is thus currently drawn at the base of the *bidorsatum* Zone (*see* Schmid 1959 for discussion).

Recent work on the microfauna of the sections at Aubeterre has shown that the bulk of the type Campanian is actually Maastrichtian as now understood (van Hinte 1965; Goharian 1971; Séronie-Vivien 1972). To try to stabilize the meaning of Campanian, Séronie-Vivien has designated parastratotype sections near Né in the Charente valley. In spite of this rationalization, it fails to provide us with a working standard for the base of the Campanian. Macro-fossils are scarce and not distinctive (Séronie-Vivien 1972, 44–46).

Since there are no means of accurate correlation with the type area, and we have no index ammonites of the lower zones of the stage in Britain, we have followed convention and placed the base of the Campanian at the base of the assemblage-zone of *Offaster pilula*. This is taken at the base of the belt of *Uintacrinus anglicus* in Sussex (Bed 5 of Brydone 1915), above the upper limit of *Marsupites* but 2 m lower than the base of the *pilula* Zone *sensu* Brydone (1914).

The Campanian zones recognized here are:

Belemnitella mucronata
Gonioteuthis quadrata
Offaster pilula

In southern England the *pilula* Zone has been divided into approximately seven units, mainly on the basis of the *Echinocorys* succession (Griffith & Brydone 1911; Brydone 1912, 1914; Gaster 1924, 1937; summary table by Peake *in* Hancock 1972, p. 114). The *quadrata* Zone is more difficult to divide, and although it can be attempted with both belemnites and echinoderms, no subzonation is agreed. The *mucronata* Zone is readily divided into subzones based on *Belemnitella* and *Echinocorys* spp. (*see* Peake & Hancock 1961; Wood 1967; Wood *in* Manning *et al.* 1970).

The Maastrichtian

The Maastrichtian Stage was introduced by Dumont (1850) with the town of Maastricht designated as type locality. The exact limits of Dumont's concept of the stage are somewhat ambiguous and have given rise to considerable controversy (*see* Voigt 1956, Deroo 1966, for a useful discussion). The stratotype has now been fixed by the Comité d'étude du Maastrichtian as the section of the Tuffeau de Maastricht—i.e. units Ma—Md of Uhlenbroek (1911)—exposed in the ENCI quarry at St. Pietersberg on the outskirts of Maastricht. Thus defined, the type Maastrichtian falls entirely within the Upper Maastrichtian Substage of current usage (Schmid

1959, 1967), corresponding with the upper part of the *Belemnitella junior* Zone, and the overlying Zone of *Belemnella kazimiroviensis.*

The divergence between the original and current concepts of the Maastrichtian Stage arises from the fact that the warm water detrital facies of the stratotype is atypical and of only local significance within the white chalk facies. A revised concept of the limits of the stage, based on the belemnite succession in the white chalk facies, is becoming increasingly accepted internationally. In this the Maastrichtian is regarded as co-extensive with the range of *Scaphites* (*Hoploscaphites*) *constrictus* and its base is marked by the entry of *Belemnella lanceolata.* However, it should be noted that several workers (e.g. Birkelund 1966) consider that *S. constrictus* comes from higher in the Lower Maastrichtian, the basal Maastrichtian being characterized by *S.* (*H.*) *tenuistriatus.* In the best-documented succession in north-west Europe which includes both ammonites and belemnites, namely Lüneburg-Zeltberg, Schmid (*in* Schmid *et al.* 1955) recorded the lowest *S. constrictus* some 8·0 m above the lowest appearance of *Belemnella* and some 45 m above the highest *Bostrychoceras polyplocum.* At this locality the lowest *Belemnella* are relatively advanced forms of the group of *B. lanceolata,* suggesting a gap in the belemnite succession, although microfaunal evidence (Hiltermann & Koch *in* Schmid *et al.* 1955) did not support this. Micropalaeontologically, the entry of *Belemnella* was found to coincide with the appearance of *Bolivinoides* ex. gr. *peterssoni, B. palaeocenica, Neoflabellina reticulata* and *Osangularia lens.*

Although the base of the Maastrichtian stage is taken at the base of the *Belemnella lanceolata* Zone and marked effectively by the entry of *Belemnella* into a previously exclusively *Belemnitella* fauna, primitive species of *Belemnella* have been recorded from the Dniepr-Donetz Basin of the Ukraine from beds underlying the *lanceolata* Zone which must, by definition, be referred to the highest Upper Campanian.

The British Maastrichtian is known only from glacially transported masses in the Pleistocene drift of the Norfolk coast and from the highest preserved levels of the Northern Ireland White Limestone. In both these occurrences the succession terminates below the top of the Lower Maastrichtian. The currently accepted zonation of the Lower Maastrichtian (*see* Schmid 1967) is adopted for these sequences; the zones are:

Belemnella occidentalis
Belemnella lanceolata

Upper Maastrichtian has been proved (by foraminifera) from various parts of the continental shelf (Curry 1962, Curry *in* Curry *et al.* 1965; Andreieff *et al.* 1975; Woodland, editor, 1975). The most important references on the subdivision of the British Maastrichtian are Peake & Hancock (1961, 1970) for the Norfolk region and Wood (1967) for the Northern Ireland succession and for a review of the British Maastrichian in general.

6. CORRELATION OF THE LOWER CRETACEOUS (FIG. 3, COLUMNS 3–12)

Speeton, Yorkshire (Column 3)

The Speeton Clay Formation is about 100 metres thick at its type locality in Filey Bay but thickens inland to reach about 400 metres in the Fordon No 1 borehole about 4·5 km west of Speeton (Dilley, in discussion of Neale 1968). Although all six Lower Cretaceous stages are represented, there are several non-sequences and the Aptian and Albian successions are particularly poorly developed. Lamplugh (1889) divided the succession into four main units, the A, B, C and D Beds (labelled from the top downward), each characterized by a belemnite genus. Bed E, the thin Coprolite Bed, forms the base of the Formation. Subdivisions of these units, based on lithology and fauna (Lamplugh 1889), provide the framework for a more detailed lithological subdivision of the D Beds by Neale (1960a, 1962a), the C Beds by Fletcher (1969), the B Beds by Kaye (1964) and the A Beds by Ennis (1937), Wright (1955, *in* Swinnerton 1936–55) and Kaye (1964). Even now the upper part of the successsion (above Lower B) is incompletely understood because of poor exposure, so that the subdivisions of the Cement Beds, Upper B and the A Beds (mid-Barremian–Albian) should be regarded with caution. The lower subdivisions provide an excellent framework for collecting faunas and calibrating their distributions against an independent, non-faunal standard.

The ammonite zones adopted here have been discussed in Section 4; ammonites are relatively rare except in the Hauterivian (Lamplugh 1924; Rawson 1971a), so that the zonation is somewhat less detailed than in Spath's (1924) idealized scheme. In contrast, belemnites are relatively common throughout, and Lamplugh (1889, 1924) and Swinnerton (1936–55) demonstrated their value in broad correlation. Lamplugh's (1889) *Acroteuthis* Zone (D Beds) was subsequently divided into 2 zones (Swinnerton 1936) and more recently into several assemblages (assemblages 2–5 and 6 pars of Pinckney & Rawson 1974). The *Hibolites* Zone (C Beds) contains rare *Acroteuthis* of assemblages 6 (pars) and 7. The recognition of a thin *Aulacoteuthis* horizon in the *Oxyteuthis* Zone (B Beds) (Rawson 1972) suggests that this zone could be further divided. Lamplugh (1924) divided the *Neohibolites* Zone (A Beds) into the *ewaldi* Zone below and the *minimus* Zone above: the latter will no doubt be further refined with the application of Spaeth's (1971) German Albian belemnite zonation to the Speeton sequence.

Neale (1960b, 1962b) described the ostracods of the D Beds with detailed species ranges. Three faunal assemblages occur, which broadly correspond with the stages and major lithofacies developments (Neale 1968). The lowest is unrepresented in north Germany, where non-marine sediments were then accumulating, but the other two faunas compare closely with north German ones (Neale 1968). The C Beds ostracods have yet to be described in detail, but the A and B Beds forms were described in a series of papers by Kaye (e.g. 1963). Neale (1973) summarizes the distribution of all these ostracods, with full bibliography. An unpublished study by

Fletcher (1966) described the foraminiferal faunas of the D, C and B Beds, and detailed range charts are now published (Fletcher 1973).

Thus there is a considerable body of information from ammonites, belemnites, foraminfera and ostracods to assist in the correlation of the Speeton Clay, though many problems remain. At the base, the phosphatic nodules of Bed E (Coprolite Bed) contain derived, indeterminate ammonites. The lowest 0·85 m of overlying clay (Beds D8–D7F) are without ammonites but *Acroteuthis* of probable Ryazanian age occur (assemblage 2 of Pinckney & Rawson 1974), together with agglutinated foraminifera (Neale 1968; Fletcher 1973). The *Peregrinoceras* beds are of high Ryazanian, *albidum* Zone, age (Casey 1973). Bed D5 is without ammonites and the microfauna consists only of long-ranging foraminifera, but the *Acroteuthis* (assemblage 3, pars) are possibly Ryazanian. Bed D4 contains Valanginian *Paratollia* and allies and Valanginian *Acroteuthis*; provisionally, we draw the base of the Valanginian at the base of D4 in the absence of firmly diagnostic faunas immediately beneath.[1]

Polyptychites occurs through D3 and D2E, but faunas of the highest part of the *Polyptychites* Zone are probably mixed with those of the *Dichotomites* and *Dicostella pitrei* Zones among abundant phosphatized ammonites in a remanié bed at the base of the Hauterivian.

Hauterivian correlations are after Rawson (1971a, 1971b). In the *inversum* Zone a 2·6 m level contains abundant *Aegocrioceras* occurring in three discrete assemblages (Rawson 1975b), all of which occur in north Germany. The Barremian correlations are indicated in the zonal discussion above (p. 13).

Correlation of the Aptian and Albian is particularly difficult because exposure is limited to isolated and transient small sections. The upper part of Upper B contains *Aconeceras nisoides* and *Prodeshayesites fissicostatus*, of basal Aptian age. The overlying A Beds are divided into three; exact terminology of the subdivisions has varied even within Lamplugh's (1924) paper, and the Greensand Streak has been attached variously to the underlying (e.g. Spath 1924) or overlying (e.g. Lamplugh 1924) beds. We prefer a tripartite division into *minimus* marls, Greensand Streak and *ewaldi* beds. Pyritized *forbesi* Zone *Deshayesites* from Speeton (in the Sedgwick Museum) presumably were obtained from about the junction of top B and the *ewaldi* beds; in southern England, the *forbesi* Zone faunas occur above the range of *Oxyteuthis* and just below the appearance of *Neohibolites* (*see* Casey 1961a). Generally, the *ewaldi* beds have been dated as Aptian; the *ewaldi* Marls of north Germany are late Lower Aptian and early Upper Aptian (Kemper 1973b) and the diagnostic belemnite has a similar range in southern England (Casey 1961a, p. 610). However, from the highest part of the *ewaldi* beds Kaye (1965) recorded ostracods which he attributed to the Lower Albian and which are distinct from those of the Sutterby Marl of Lincolnshire (*see* Kaye & Barker 1965), with which the *ewaldi* beds have often been correlated. The discrepancy in dating may be because the

---

[1] One of the authors (J.W.N.) dissents from this decision and prefers to continue drawing the boundary at the major lithological and environmental break at the base of D5.

lower part of the *ewaldi* beds (barren of ostracods) was the main source of *Neohibolites ewaldi* (Lamplugh 1924); the beds are regarded provisionally as spanning from mid-Aptian to earliest Albian times, though there could be gaps in the sequence.

The Greensand Streak has yielded *regularis* Subzone foraminifera (Dilley 1969) and *Leymeriella* (Spath 1924, confirmed by Casey) and is dated to the upper *tardefurcata* Zone. However, Kaye (1965) regarded the ostracods as indicating a mid Albian age. The overlying *minimus* marls have yielded *Hoplites* cf. *dentatus* and *Inoceramus concentricus* about 0.3 m above the base (Lamplugh 1924; the ammonite identified by Spath), and higher horizons have yielded early Upper Albian *Euhoplites* and *Mortoniceras* (Wright *in* Swinnerton 1955) and *Anahoplites trifidus* (Spath 1924). These marls grade up into the Red Chalk, which is some 6 metres thick on the coast, thickens to about 30 metres in the North Fordon G.2 borehole, and then reduces rapidly to about a metre at outcrop in the western part of the wolds. It is probably all of late Albian age in these northernmost outcrops, and the topmost level on the coast yields the late Albian belemnite *Neohibolites ernsti* (Spaeth 1973).

Lincolnshire (column 4) *and southern East Yorkshire*

Throughout the early Cretaceous the Market Weighton Hinge formed a stable, positive region between two gently subsiding basins. Transgressive Albian deposits straddle the hinge, but pre-Albian Lower Cretaceous rocks are absent between Audleby (north Lincolnshire) and immediately south of Knapton (Yorkshire), a distance of about 70 kilometres.

Lamplugh (1896) produced a detailed summary of the Lincolnshire Lower Cretaceous, but significant additions to our knowledge were made by Swinnerton (1935, 1936–55, 1941). The succession was reviewed by Wilson (1948) and Swinnerton & Kent (1949), since when much new information has become available though little has been published. The sequence is most complete in south-east Lincolnshire, where there are up to 80 metres of strata of Ryazanian-Albian age. Northwards, the sub-Carstone Grit (Lower Albian) unconformity cuts out successively older beds until north of Audleby the Carstone rests on Upper Jurassic clays (Strahan 1886). Further north, on both sides of the Humber, the Carstone Grit is patchily developed; where it disappears the base of the Red Chalk is conglomeratic (Hill 1888; Strahan 1886). In the central region of the Hinge, pebbly Red Chalk rests on Lower or Middle Lias (Lower Jurassic).

The base of the Cretaceous falls within the Spilsby Sandstone (*see* Casey 1973), and is drawn at the mid-Spilsby nodule bed which defines the base of the Upper Spilsby Sandstone. *Surites* spp. in the nodule bed indicate the *icenii* Zone (Upper Ryazanian) and the earlier Ryazanian zones are missing. The upper part of the Upper Spilsby Sandstone yields *Bojarkia stenomphala* and allies in south Lincolnshire, whilst the topmost beds in the Fordington borehole and at Biscathorpe contain *albidum* Zone faunas (Casey 1973). While there is a passage from Upper Spilsby Sandstone to the Claxby Beds in south Lincolnshire, further north the Upper Spilsby

Sandstone is cut out and the Claxby Ironstone rests on Lower Spilsby Sandstone, of Volgian age.

In northern Lincolnshire the Claxby Beds are represented by the oolitic Claxby Ironstone; to the south and southeast more argillaceous bands appear and in the vicinity of Spilsby much of the ironstone passes laterally into the Hundleby Clay. The lower boundary of the Claxby Beds is diachronous, though accurate dating is difficult because ammonites are sparse. Ryazanian (*albidum* Zone) *Peregrinoceras* occur in an ironstone facies at the base of the Hundleby Clay of East Keal brickyard, and in the basal Claxby Ironstone at Asterby and Winceby. Early Valanginian *Paratollia* and *Propolyptychites* are known from the lowest Claxby Ironstone at Benniworth Haven.

Later Valanginian *Polyptychites* of the *gravesiformis* group occur in the Hundleby Clay, and similar forms are common in a condensed horizon at the top of the Claxby Ironstone of Nettleton, where they are mixed with *Dichotomites*, *Neohoploceras* and early Hauterivian *Endemoceras* of the *amblygonium-noricum* Zones (Penny & Rawson 1969). Here there is a non-sequence between the ironstone and the Lower Tealby Clay, the *regale* Zone fauna being absent (Rawson 1971a, p. 34). The ironstone yields the characteristic Speeton D Beds belemnite *Acroteuthis* throughout. Further to the southeast, oolitic clays which Swinnerton (1935) assigned to the Upper Claxby Ironstone but which are better included in the Lower Tealby Clay represent this gap, for not only is *Acroteuthis* replaced by *Hibolites* in these beds, but a well-preserved *Endemoceras regale* (GSM. Zn 5163: recorded by Swinnerton (1935) as *Lyticoceras oxygonium*) was obtained from the Alford borehole.

The bulk of the Lower Tealby Clay yields occasional *Aegocrioceras*, *Crioceratites* and *Simbirskites*, together indicating the *inversus* Zone to probable early *variabilis* Zone (Rawson 1971a, p. 34), while the distinctive, widespread late Hauterivian species *Simbirskites* (*Craspedodiscus*) *discofalcatus* (Lahusen) occurs in the Tealby Limestone. No ammonites have been recorded from the Upper Tealby Clay.

Belemnites are relatively common throughout the Tealby Beds: *Hibolites jaculoides* occurs through the Lower Tealby Clay into the base of the Tealby Limestone, while *Oxyteuthis pugio* and allies occur in the main part of the Limestone. Records of *Aulacoteuthis* from the Upper Tealby Clay (Swinnerton 1935) indicate a mid-Barremian age (Rawson 1972).

Work on the Tealby Beds microfaunas has been sporadic and unsystematic, and while there is a general correspondence with the Speeton faunas no detailed successional work has been attempted. Microfaunas have been described from the Lower Tealby Clay of Nettleton Valley, South Humberside (Bartenstein 1956) and ostracods from the Upper Tealby Clay of Dalby Hill, Lincolnshire (Kaye & Barker 1966).

The Fulletby Beds are predominantly argillaceous and ferruginous, with a prominent harder, sandy and ferruginous horizon (the Roach Stone) in the middle. The lithologies have been described by Owen & Thurrell (1968). Fossils are rare but *Oxyteuthis* of the *germanicus* group occur in the Lower Roach and rare rhynchonellids in the Roach Stone. The considerable increase in thickness of the Fulletby Beds in the Skegness waterworks borehole (*see* Swinnerton 1935) when compared with the underlying Tealby Beds may indicate that here the Fulletby Beds facies set in earlier. The Fulletby Beds are overstepped by the Carstone Grit north of the Belchford region.

The Skegness Clay (Gallois 1975b) has yielded *in situ* ammonites of the lower part of the *fissicostatum* Zone, and *Hibolites minutus*. It is known only from boreholes, where it was formerly confused with the overlying Sutterby Marl. The latter is poorly exposed, but the basal beds have yielded an extensive phosphatized fauna from excavations and boreholes (Swinnerton 1935). The ammonites represent three different Lower Aptian zones (Casey 1961a, p. 570), including forms derived from the Skegness Clay. The marl above is late Aptian (Casey 1961a), as evidenced by a single ammonite (*Colombiceras*) and the very late early Aptian age of one of the underlying phosphatized faunas; it contains ostracods of Barremian-Aptian aspect (Kaye & Barker 1965). Both the basal nodule beds and the bulk of the marl contain numerous *Neohibolites ewaldi.*

The Langton 'Series' were divided by Swinnerton (1935) into the Carstone Sands and Clays below and the Carstone Grit above, and are generally unfossiliferous. The Grit oversteps the sands and clays and successively older beds when traced northwards from south Lincolnshire, and everywhere grades up into Red Chalk. Near the Humber, where it is only patchily developed, the Grit is represented locally by finer sands, sometimes slightly argillaceous. At Melton (east Yorkshire) these have yielded brachiopod species known from the Shenley Limestone (Owen, Rawson & Whitham 1968), of probable early Albian age, and early Albian foraminifera (Dilley 1969). The brachiopod fauna is represented also at South Ferriby (north Lincolnshire) (Smart & Wood 1976) and in temporary sections exposed during the construction of the Brigg by-pass. At Elsham, north Linconshire, a clay at the base of these beds contains a late Aptian-early Albian foraminiferal fauna close to that of the Sutterby Marl (Kent & Dilley 1968). This clay rests on the Kimmeridgian Elsham Sandstone.

The Red Chalk or Hunstanton Red Rock is a thin but remarkably persistent horizon which extends from Hunstanton on the Norfolk coast to Speeton in Yorkshire, and is also extensively developed in the North Sea region (Kent 1967). *Neohibolites minimus* occurs throughout and *N. ernsti*, an indicator for part of the Upper Albian, in the highest beds (Spaeth 1973). Rare *Mortoniceras* are known from South Ferriby (Smart & Wood 1976) and Redhill, *Hoplites* (Rawson colln) from Nettleton and *Dimorphoplites* (Owen *et al.* 1968) from Melton, together indicating a mid to late Albian age.

Norfolk (Column 5)

Natural exposures are few, but quarries and temporary sections have recently provided much new information. The succession, with map, is reviewed in detail by Larwood (1961); the subdivision of the Sandringham Sands is after Casey & Gallois (1973), who have also proposed the term Dersingham Beds to embrace both the Snettisham Clay and its more sandy correlatives and associates. In general, the

Lower Cretaceous thins and becomes more sandy southwards so that the Snettisham Clay disappears in the vicinity of West Newton and the whole of the pre-Red Chalk sequence becomes sandy. Conversely, the Red Chalk passes southwards into red marls, and eventually into typical Gault Clay near Narborough.

The lower part of the Sandringham Sands is of Volgian (Jurassic) to Ryazanian age (Casey 1973) and the Mintlyn Beds contain the most complete Ryazanian ammonite sequence recorded in Britain. Evidence of intra-Ryazanian movements is seen in the northwards reduction of the *Hectoroceras kochi* Zone from 9 metres of sands and clay-ironstone bands at West Dereham to a few centimetres of nodular phosphorite near Kings Lynn. The overlying *Lynnia icenii* Zone is in a similar condensed facies here. The highest, poorly fossiliferous, Leziate Beds are probably Valanginian. The overlying Dersingham Beds yield Lower Hauterivian *Endemoceras* at their base and Lower Barremian *Paracrioceras* and *Acrioceras* in the Snettisham Clay facies. Upper Barremian crioceratitids in a Snettisham Clay matrix occur in glacial erratics in the Gipping Till of this region, suggesting that higher horizons of the Snettisham Clay are preserved below the Albian unconformity in the nearby North Sea. At Hunstanton there is a thin representative of the Fulletby Beds beneath the Carstone (Gallois 1975a).

The remanié Lower Aptian fauna at the base of the Carstone (Lower Greensand) has been described by Casey (1961a). At West Dereham, where the Carstone rests on the Sandringham Sands (Mintlyn Beds), the fauna occurs along with derived *Hectoroceras* in the basal conglomerate, which later provided anchorage for Lower Albian brachiopods (Casey 1967). Ammonites of the topmost *tardefurcata* Zone and of the *mammillatum* Zone occur in phosphatic nodule beds in the Carstone at this locality. The sedimentary features show a transition from the condensed Lower Albian of the Leighton Buzzard district (Bedfordshire) to the typical Carstone facies.

Rare ammonites in the Red Chalk at Hunstanton indicate a span from the *dentatus* Zone (Lower Albian) to the *inflatum* Zone (Upper Albian). The Upper Albian belemnite *Neohibolites ernsti* occurs in the topmost bed.

The North Sea (Column 6)

Stratigraphic columns for southern North Sea wells 48/22-2 and 49/24-1 were published by Rhys (1974); one is included here (Fig. 3). They demonstrate the extension of Spilsby Sandstone, Speeton Clay and Red Chalk equivalents some 150 km east of East Anglia, with maximum thicknesses of the same order of magnitude as onshore. Rhys (1974) included the three lithological units as formations within a Cromer Knoll Group.

In the southern North Sea, stratigraphical relationships within the Lower Cretaceous and with underlying beds show that although continuous sedimentation from late Jurassic to early Cretaceous times may be expected locally, the effects of the main late Kimmerian and subsequent tectonic events and of salt movement (which persisted throughout the Cretaceous), have resulted in both local and widespread unconformities, with the more important intra-Lower Cretaceous transgressive phase during the Aptian/Albian (Kent 1975b).

In the northern North Sea, tectonic influences persisted but halokinetic movements were less important. The lowest Cretaceous is commonly Hauterivian or Barremian (Johnson 1975) but earlier Cretaceous sediments accumulated in the grabens, where total Lower Cretaceous thickness increases to as much as 500 m (Ziegler 1975). Here there are strong indications of deeper-water environments in the microfaunal associations. Red colouration of sediments is found virtually to the farthest north yet explored, and is not limited to the Albian.

Off the eastern coast of Scotland, the Moray Firth basin has been mapped by the Institute of Geological Sciences (Chesher *et al.* 1972): the existence of Cretaceous sediments on the sea floor has long been suspected because of the occurrence of fossiliferous glacial erratics on the Moray Firth coast (e.g. Tait 1909; Lee & Pringle 1932). Lower Cretaceous black shales overlie Kimmeridgian black shales in the central part of the Firth (Chesher *et al.* 1972): sampled horizons are Barremian but older strata are apparently present. In two boreholes slightly nearer the present coastline, barren sandstones of presumed Lower Cretaceous age occur, but their relationship with the shales is not known. The onshore glacial erratics are of fine-grained sandstones with diverse faunas including poorly preserved ammonites and belemnites of probable Hauterivian and Barremian age (I.G.S. Edinburgh, Aberdeen University and Rawson collections) and the distinctive Valanginian to Hauterivian brachiopod *Rugitela hippopus.* Spath (1924, p. 81) recorded *Polyptychites* cf. *triplodyptychus*, of late Lower Valanginian age, from Culgower, near Helmsdale.

Cambridgeshire and Bedfordshire (Column 7)

Deposition was in a narrow seaway round the western margin of the Anglo-Brabant Massif, linking the East Midlands shelf with the Wessex basin. The sedimentary record is patchy; the oldest strata (Woburn or Potton Sands) are Aptian. However, the occurrence of derived blocks of Volgian (Jurassic) sandstone raises the possibility of the former presence of some pre-Aptian Cretaceous also. While most horizons of the Woburn Sands are unfossiliferous, lower layers are locally very rich and at Upware and Brickhill yielded abundant fossils (especially brachiopods) from 'coprolite' workings (e.g. Keeping 1883; Middlemiss 1959; Casey 1961a). Ammonites are rare in the sands, but remanié early Aptian forms occur at the base while the bulk of the sands is late Aptian.

Around Leighton Buzzard (and at Long Crendon, 19 km to the south-west) a variable series of beds with a complex depositional history (Owen 1972) occur between the Woburn Sands and the Gault. They include phosphatic nodule horizons and lenticular masses of Shenley Limestone, the latter containing *regularis* Subzone ammonites and a rich brachiopod fauna. Laterally, the lenticles are replaced by a Carstone breccia very similar in general lithology to the Carstone Grit of Norfolk and Lincolnshire.

The Gault overlaps the Lower Greensand to rest on Jurassic strata, but it is poorly exposed and knowledge of thickness is derived mainly from boreholes. It is 27 m

(90 ft) near Soham, Cambridgeshire, 36 m (120 ft) near Cambridge (Worssam & Earp *in* Worssam & Taylor 1969) and thickens southward to some 60 m (200 ft), with an overlying 6 m (20 ft) or so of Upper Greensand, in southern Bedfordshire. Under cover of the Chalk it oversteps onto Palaeozoic rocks and is 48 m (160 ft) thick, with 12 m (40 ft) of overlying Upper Greensand, in the Ware and Cheshunt (1879) boreholes. The Upper Gault (Upper Albian) was formerly believed absent (Jukes-Browne & Hill 1900) but is now known at several localities (e.g. Worssam & Taylor 1969). In the vicinity of Cambridge the overlying Cenomanian Cambridge Greensand (see p. 50) has yielded as a remanié assemblage one of the best uppermost Albian (*dispar* Zone) faunas in the country.

The Weald (Column 8)

Although the Cinder Bed horizon is difficult to map, it is recognized in boreholes. In the centre of the Wealden basin the Cinder Bed and overlying part of the Purbeck (Durlston Beds) total about 70 m in thickness (Howitt 1964; Anderson & Bazley 1971) and on its northern flank they are 32 m thick in the Warlingham borehole (Worssam & Ivimey-Cook 1971). The Purbeck-Wealden boundary is gradational.

The Wealden Beds vary considerably in facies and thickness, reflecting an unstable sedimentary environment. Allen (1976) has revised his former theory (Allen 1959) of deltaic sedimentation in favour of a model in which the 'normal' Wealden environment was a variable-salinity mudplain, periodically transformed into braided sandgurs by powerful overloaded streams. The environments indicated by plant fossils are discussed by Batten (1975).

Sedimentological and lithostratigraphical evidence indicates that a boreal sea may have had more influence than the sea in the south-east part of the Paris basin in causing the brackish-marine incursions in the Wealden Beds (Casey 1963; Allen 1965; Worssam & Ivimey-Cook 1971, pp. 28–52). Three main incursions are recognized, the earliest represented by the Wadhurst Clay, the next by the higher beds of the lower division of the Weald Clay (the Henfield 'Group' of Anderson 1971), and the latest by top Weald Clay brackish-marine bands.

The Wealden Beds are divided into the Hastings Beds and the Weald Clay. The Hastings Beds are a variable group of sandy and more argillaceous units which thicken towards the centre of the Weald, where they are more than 400 m thick. When traced eastwards into the Kent Coalfield area individual units thin and lose their separate identities (Allen 1967), though they remain distinct in the Warlingham Borehole, where the Hastings Beds total 80·7 m, with probably only a few metres lost by faulting.

The nomenclature of the Hastings Beds subdivisions is discussed by Bristow & Bazley (1972). The Fairlight Clay (White 1928) is not now separately distinguished from the Ashdown Beds (Anderson & Bazley 1971, pp. 21–22; Bristow & Bazley 1972, p. 36). The Grinstead Clay occurs to the west of a line trending south-south-west through Tunbridge Wells; eastward the Tunbridge Wells Sand is not separable into Lower and Upper Divisions. The top part of the Lower Tunbridge Wells Sand (sandrock facies) is the Ardingly Sandstone. Where the Cuckfield Stone occurs within the Grinstead Clay, Lower and Upper divisions are recognized in the clay.

The Weald Clay is thickest in the western Weald, where it may attain 450 m (Thurrell, Worssam & Edmonds 1968). On the northern flank of the basin it is 175·8 m thick in the Warlingham borehole, 122 m in the Hothfield borehole (Lamplugh, Kitchin & Pringle 1923) and around 10 m thick in east Kent boreholes. On the southern flank of the Weald a total thickness of 151·8 m has been proved in the Ripe borehole (Institute of Geological Sciences 1973, p. 126).

Two main lithostratigraphical divisions are recognized in the Weald Clay, though they are not formally named. The lower division corresponds to the lowest of the three cyclothems described from the Maidstone area (Worssam 1963). It is characterized by small-'*Paludina*' limestones, which occur as discontinuous layers in the upper levels of the unit. The '*Paludina*' is commonly identified as *Viviparus elongatus* (J. de C. Sowerby) but is more appropriately named *V. infracretacicus* Huckriede (A. A. Morter, personal communication). At the western end of the Weald, the Horsham Stone occurs near the base of the division, while there are one or more brackish-marine bands near the top (Worssam & Thurrell 1967).

The upper division comprises the higher two of the three cyclothems described from the Maidstone district. It is characterized by the occurrence in the lower part of beds of large-'*Paludina*' limestone, composed of *Viviparus* now identified (by A. A. Morter) as *V. fluviorum* (J. Sowerby *non* de Montfort = *V. sussexiensis* auctt). Brackish-marine bands occur near the top of the division.

Biostratigraphic correlation within these Purbeck/Wealden facies is effected principally by means of ostracod assemblage zones (e.g. Anderson 1967, 1973), which are often identifiable in other areas of Europe and even further afield (Anderson 1973). Correlation with marine successions is much more difficult to achieve and the tie lines with the standard stages on the main correlation chart are very provisional. Allen (1967) concluded that the Durlston-Hastings Beds succession is substantially Ryazanian-Valanginian. On palynological evidence, the top Fairlight Clay (of White 1928) is probably early Valanginian (Hughes & Croxton 1973) while the upper part of the Ashdown Beds at Warlingham is Valanginian (Hughes & Moody-Stuart 1967). Palynological evidence also places beds at 504·4 m (1655 ft) in the Warlingham borehole in the late Valanginian; these are assigned to the Upper Tunbridge Wells Sand (Worssam & Ivimey-Cook 1971). This agrees with Anderson's (1973) placing of the Valanginian-Hauterivian boundary at the top of the sands. Other palynological evidence (N. F. Hughes, personal communication) indicates that the top Wadhurst Clay in east Sussex is late Valanginian.

Allen (1955, 1959, 1965, 1967) has long considered that the Weald Clay probably spans the Hauterivian and the entire Barremian, and this is supported by spore (Hughes & Moody-Stuart 1967) and ostracod (Anderson 1973, Fig. 1) evidence. Only one ostracod species is known in both the Wealden Beds and the marine boreal Lower Cretaceous. This is *Paranotacythere diglypta*, recorded from the Lower Hauterivian of Yorkshire, West and East Germany (Neale 1973, Table 1) Poland, the Paris Basin and from the upper part (Henfield 'Group') of the lower division of the Weald Clay (Anderson *et al.* 1967, p. 191). Hughes (1973) suggested that beds at

405·4 m (1330 ft) in the Warlingham borehole, just above the base of the upper (large-'*Paludina*') division, are early Barremian. Therefore, on present evidence the Hauterivian-Barremian boundary can be taken at the junction of the lower and upper divisions of the Weald Clay. This is at a transition to less saline conditions, which is in line with evidence from much of Europe for extension of marine conditions during the Hauterivian followed by deterioration of the marine environment during the Barremian (e.g. Fletcher 1973; Kemper 1973a; Middlemiss 1973).

The Lower Greensand has been described in detail by Casey (1961a) and the correlations in the main and subsidiary charts follow that work. The Atherfield Clay rests with sharp contact on the Weald Clay, and the basal beds are not always of the same age, being *fissicostatus* Zone in Surrey and west Kent (and in the Isle of Wight) and *forbesi* Zone in east Kent.

The Hythe Beds become more arenaceous westwards from the calcareous 'rag and hassock' facies of Kent, and the overlying Sandgate Beds shows even greater facies change: in the eastern Weald (Kent) they consist of loams, silts and silty clays, but westwards pass into more varied facies in Surrey and parts of Hampshire (e.g. Kirkaldy 1933). Fuller's earth beds within the Sandgate Beds may correlate with montmorillonite clays in north Germany (Kemper 1973b). The calcareous sandstones of the Folkestone Beds on the Kent coast thicken inland into false-bedded sands, reaching a maximum of almost 80 metres (260 ft) around Farnham, Surrey, in the western Weald.

In Sussex, the Lower Greensand thins south-eastwards as a result of contemporaneous movement along the Portsdown axis. The Atherfield Clay and Hythe Beds lose their identity and eventually, in the vicinity of Eastbourne, the whole series is represented by thin glauconitic loams with phosphatic nodules beneath the Gault. Earth movements towards the close of the period of deposition of the Lower Greensand produced a sudden change in the sedimentary pattern traceable throughout the Weald (mid-*tardefurcata* break of Casey 1961a).

The boundary between the Lower Greensand and the Gault is generally gradational, though occupying only a metre or two of strata. It is also diachronous though mainly within the *mammillatum* Zone. The Gault is therefore of Middle and Upper Albian age. The type locality is at Folkestone at the eastern end of the Weald, and the Gault is still exposed in several inland brick pits. Owen (1971) has detailed many Lower Gault (Middle Albian) sections and much local information is included in recent Geological Survey memoirs (e.g. Smart *et al.* 1966; Dines *et al.* 1969).

At Folkestone, where the ammonite succession is very well known, there are several faunal breaks, usually indicated by seams of phosphatized fossils, and this is true inland. The most important and widespread break is at the base of the transgressive Upper Gault. Hart's (1973c) detailed microfaunal zonations also indicate regional and local breaks in the Gault succession.

Isle of Wight (Column 9)

The Arreton borehole (Falcon & Kent 1960) indicates a total Purbeck Beds thickness of 104 m and a Wealden Beds thickness of 612 m. At outcrop, the

Wealden Beds comprise Wealden Marls, of which the top 170 m are exposed, overlain by Wealden Shales 51–58 m thick. Hughes (1958) dated the marls exposed on the coast as Barremian, and the Wealden Shales appear to belong largely to the *Cypridea valdensis* Zone (Anderson 1967, p. 261) of presumed late Barremian age.

Much of the southern part of the Island is occupied by Lower Greensand, which reaches its maximum thickness of over 260 m on the south-west coast between Atherfield Point and Rocken End. The succession in Figures 3 and 4 is based on the pioneer work of Fitton (e.g. 1847) as revised by Casey (1961a). Correlation with the standard ammonite zones (which were defined largely as a result of collecting from the island) follows Casey (1961a, Table 1). The Perna Beds, at the base of the Atherfield 'Group', rest erosively on the Wealden Shales. Two beds, the Crackers and Upper Lobster Beds, are included in the Atherfield 'Group' (Casey 1961a) though the Geological Survey placed them in the Ferruginous Sands. The latter are divided into 'Groups' IV–XV, and embrace equivalents of the Hythe and Sandgate Beds of the mainland. 'Groups' XI, XII and XV are sparsely fossiliferous and their zonal assignment is tentative; 'Group' XV is apparently the correlative of the Marehill Clay of the Pulborough area, Sussex.

The overlying Sandrock and the Carstone are the correlatives of the Folkestone Beds of the Weald. Depressingly poor in fossils, the Sandrock has yielded at Luccomb Chine a few examples of *Hypacanthoplites rubricosus* of the middle part of the *jacobi* Zone. These occur in a nodular seam near the base. An isolated find of *H.* aff. *trivialis* at Dunnose suggests that the Sandrock sequence terminates in the *milletioides* Subzone (middle of the *tardefurcata* Zone) of the Lower Albian. The sharp junction of the Sandrock and Carstone is a local expression of the widespread phase of movement responsible for the 'mid-*tardefurcata* break' of Casey (1961a). Species of *Sonneratia* characteristic of the *kitchini* Subzone (basal *mammillatum* Zone) occur in the basal beds of the Carstone, and finds of *Otohoplites, Protohoplites* and *Cleoniceras* indicate that all three succeeding subzones of the *mammillatum* Zone are present above. The junction with the Gault is gradational and ammonites of the *eodentatus* Subzone (basal *dentatus* Zone) of the Middle Albian still occur in a gritty Carstone matrix.

Middle Albian occurrences were reviewed by Owen (1971), mainly from coastal exposures of Gault (often obscured by slipping) and from the inland workings at Rookley. Only the *dentatus* Zone has been proved. At Redcliff, the Gault facies apparently extends into the lower part of the Upper Albian (Owen 1971, p. 43), but generally the Upper Albian is in Upper Greensand facies. Occasional ammonites indicate the presence of both the *inflatum* and *dispar* Zones.

Dorset and Devon (Column 10)

The outcrops represent a westerly thinning extension of the Isle of Wight sequence. In Dorset, the Durlston Beds total about 60 m, and the boundary between these and the Wealden Beds is gradational. The Cinder Bed horizon at the base of the Durlston Beds is taken as the base of the Ryazanian; the indirect evidence that initially led to this conclusion (Casey 1963, 1973) is supported by ostracod (Anderson 1973) and palynological (Davies *in* Casey *et al.* in press) evidence.

The thickness of the Wealden Beds exceeds 600 m at Swanage but diminishes westwards to about 420 m at Worbarrow; they comprise the Variegated Marls and Sandstones, overlain by Wealden Shales. The latter are only 10 m thick at Swanage and are absent at Worbarrow. At one locality (Corfe Station) Wealden Shales appear to pass laterally westwards into beds of sandy clay facies (Arkell 1947, p. 156). Near Swanage the shales have an ostracod fauna typical of the upper part of the *Cypridea valdensis* Zone (Anderson 1967, p. 261).

The Lower Greensand of Dorset is some 60 m thick at Swanage, diminishing westwards to 35 m at Worbarrow Bay. The correlation follows Casey (1961a), who gives evidence for the westward passage from a marine to a brackish-water ('Wealden') facies in the lower beds, this being particularly well demonstrated by the Punfield Marine Band, 0·3 m thick, at the top of the Atherfield Clay. The Gault and Upper Greensand of Dorset are described by Wright (*in* Arkell 1947, pp. 178–194). The best exposure is at Worbarrow Bay where the thickness totals 57 m. The Gault transgresses westwards over folded and eroded earlier Cretaceous and Jurassic rocks (Owen 1971, Fig. 23).

In Devon, only Albian sediments are present, developed essentially in an arenaceous facies and resting unconformably on Devonian to Lower Jurassic rocks; *loricatus* Zone silty Gault occurs at the base of the succession in the eastern part of the area (Lang 1914; Hancock 1969; Edmonds *et al.* 1969, Fig. 18). The remainder of the coastal succession westwards as far as Sidmouth is divided into a lower group of glauconitic sands (Foxmould) and an upper group of calcarenites with chert beds (plus Top Sandstones: for details see Jukes-Browne & Hill 1900; Tresise 1960; Smith 1961). Although the chert beds have been attributed to the Cenomanian on microfaunal evidence (Hart 1973b; Carter & Hart, in press) the occurrence of a high *dispar* Zone ammonite assemblage (Hamblin & Wood 1976) near the top provides unequivocal evidence of an Upper Albian age.

West of Sidmouth, the Greensand succession is non-calcareous—the Blackdown facies of Tresise (1960). It includes the poorly exposed Blackdown Greensand, which formerly yielded a superbly preserved silicified molluscan fauna from underground workings (Downes 1882). The chert-bearing horizons of the Blackdown Greensand are not the equivalent of the chert beds of the coast but correlate with part of the Foxmould.

For the geographically isolated Greensand succession of the Haldon Hills outlier west of the river Exe we follow Hamblin & Wood (1976, with review of previous work on the Devon Upper Greensand), who proposed a quadripartite Haldon Sands Formation of which the lowest three members are Albian. This classification is broadly applicable to the Greensand of the Bovey and Decoy basins to the south, although there the lowest member is missing and the succession is much more marginal in character, due to proximity to the shoreline; in contrast to the non-calcareous Haldon Hills succession, there are local developments of calcarenites and orbitoline limestones which have been attributed erroneously to the Lower

Cenomanian. Full details and comprehensive faunal lists of the Haldon Sands including the coral bed are given by Hamblin & Wood *in* Selwood *et al.*, in press.

The western outcrops: *Wiltshire to Buckinghamshire* (Column 11)

From the Ryazanian to the early Albian this depositional area formed a westerly margin to the Wessex basin, and pre-Gault Cretaceous occurs only in widely separated patches, being mostly the sedimentary record of three transgressive episodes that took place in the early Ryazanian, late Aptian and early Albian.

The Cinder Bed horizon, marking the base of the non-marine Ryazanian, is traceable in the Vale of Wardour, south Wiltshire. It is not seen for 25 km under Salisbury Plain, but reappears in the Vale of Pewsey and continues (in near-marine Whitchurch Sand facies) some 120 km north-eastward to Stewkley, Buckinghamshire, in places overstepping the Lulworth Beds of the Purbeck to rest on Portland Beds (Casey & Bristow 1964). It is only a metre or two in thickness.

The so-called 'Wealden Beds' of Shotover, Wheatley and Milton, Oxfordshire (Shotover Ironsands), 20 m thick, have yielded no fossils of correlative value; they have been equated with the Hastings Beds (Taylor 1959) or the Weald Clay (Ballance 1964). South of Aylesbury, Buckinghamshire, there are a few other patches of ferruginous sands of dubious relationships, some (e.g. at Stone) reputedly having molluscs and plants of Wealden type (Morris 1867).

Evidence of the late Aptian (*nutfieldiensis* Zone) trangression is found along the forward edge of the Gault in Berkshire and Wiltshire, where up to 50 m of Lower Greensand deposits of highly individual character are entrenched into the Jurassic (*see* Casey 1961a). These include the Faringdon Sponge Gravels and the Seend Ironsand. Thin glauconitic sands of early Albian (*mammillatum* Zone) age are more widespread at the base of the Gault and overlap onto the Kimmeridge Clay. Certain other unfossiliferous sands running parallel with the Gault, such as the Red Sands of Uffington, in the Vale of the White Horse, Berkshire, and the Bedchester Sands near Shaftesbury (White 1923) may be early Albian (Casey 1961a, pp. 564–5).

In this region the Gault is estimated to reach 80 m in thickness. The lower part of the Middle Albian (*dentatus* Zone) is well represented (e.g. at Thame, Buckinghamshire, and Culham, Oxfordshire), but only vestiges of the high Middle Albian have survived the late Albian transgression (Spath 1943). Upper Albian Gault Clay facies are well known in the vicinity of Aylesbury and the succeeding Upper Greensand facies is represented by the Malmstone (with the Potterne Rock in Wiltshire), of late Albian age, which runs through Wiltshire and Oxfordshire into Buckinghamshire.

The English Channel (Column 12) *and Western Approaches*

Cretaceous rocks underlie some two-thirds of the floor of this region and are exposed over nearly one-third of its surface (see maps in Boillot & Musellec 1975 and Smith & Curry 1975, and Fig. 5 here). The facies in which they occur are similar to those known on nearby land. Lower Cretaceous beds are believed to be present over almost the whole area north-east of a line from Portland to Le Havre. In the region immediately south-west of this line they are absent (Dingwall 1971, p. 10).

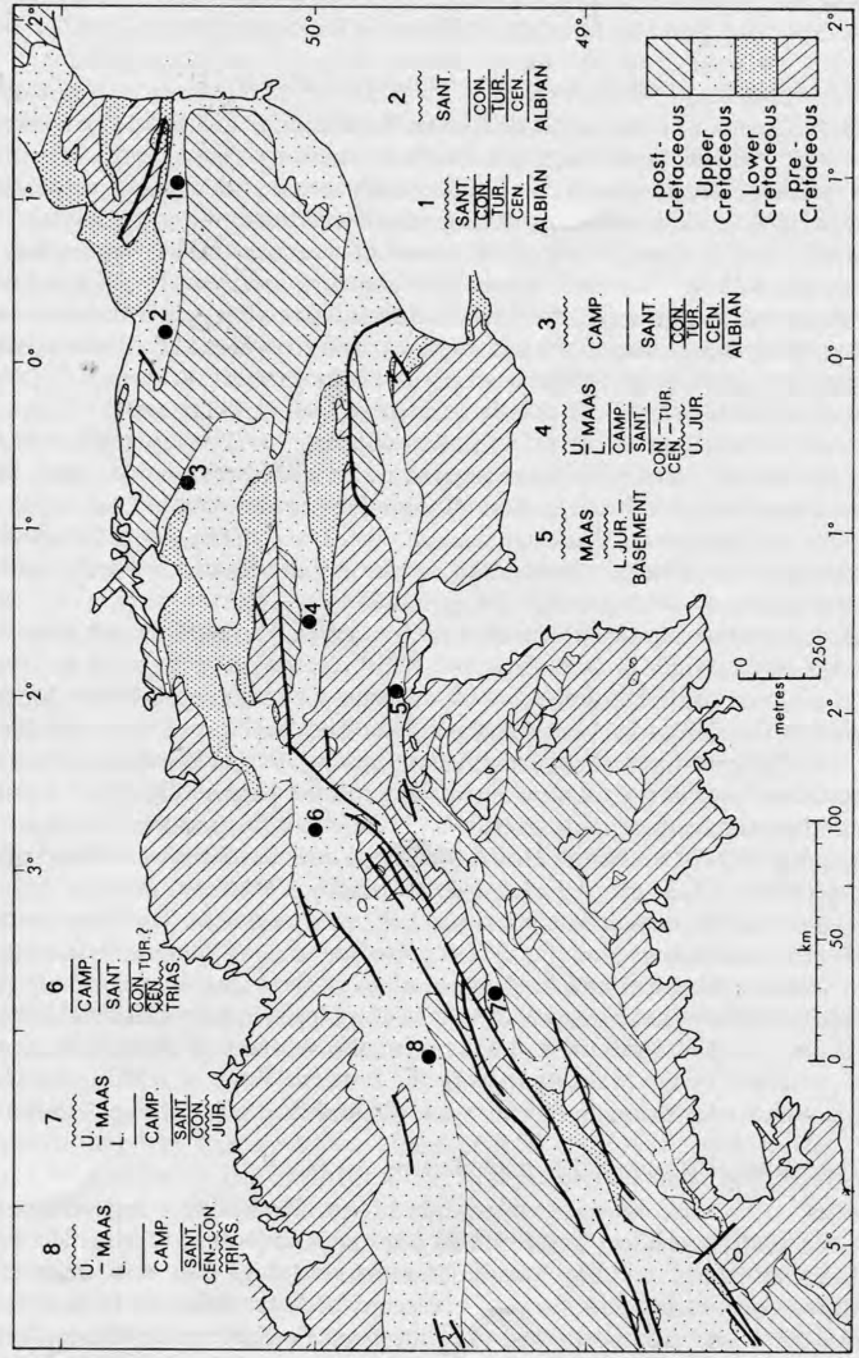
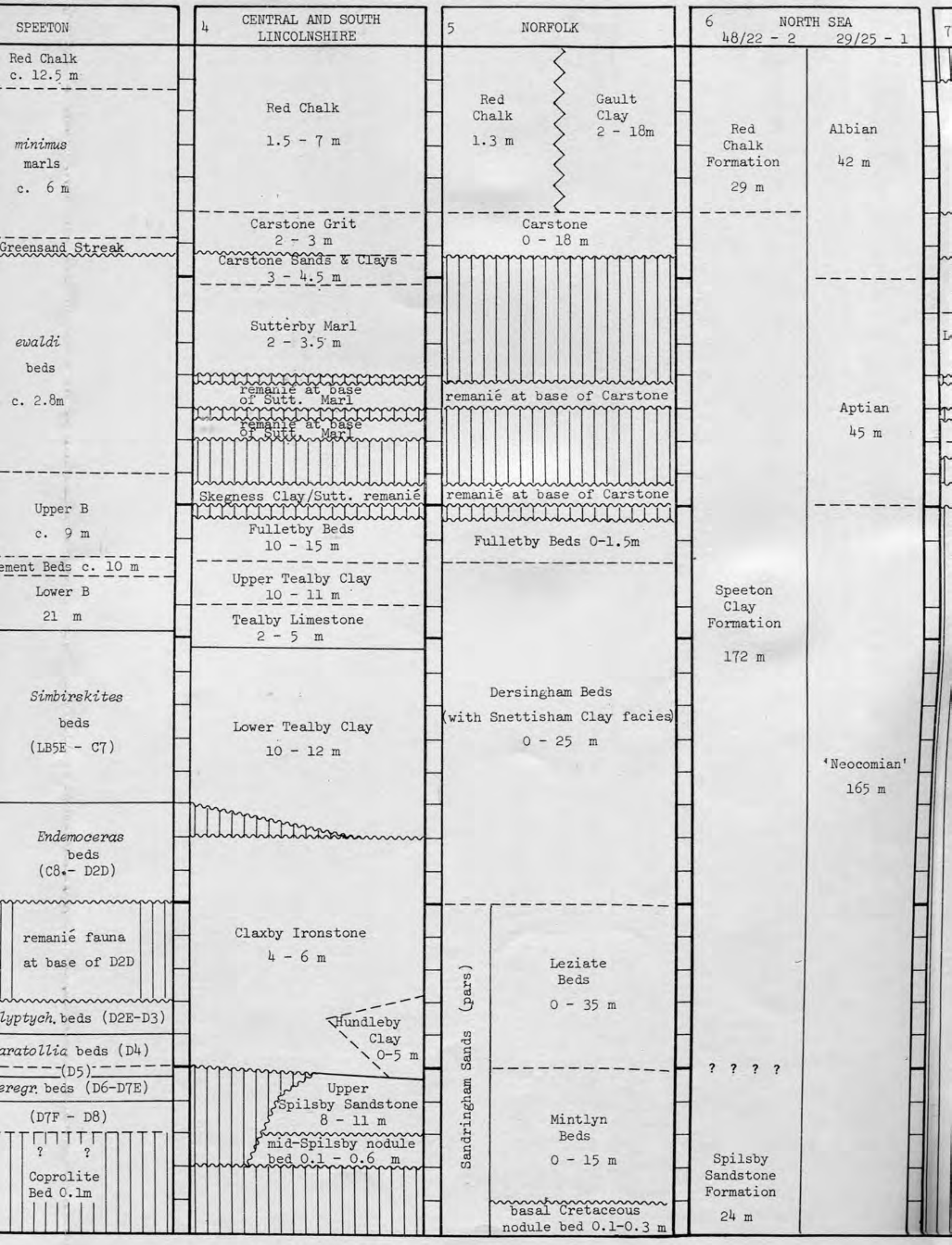
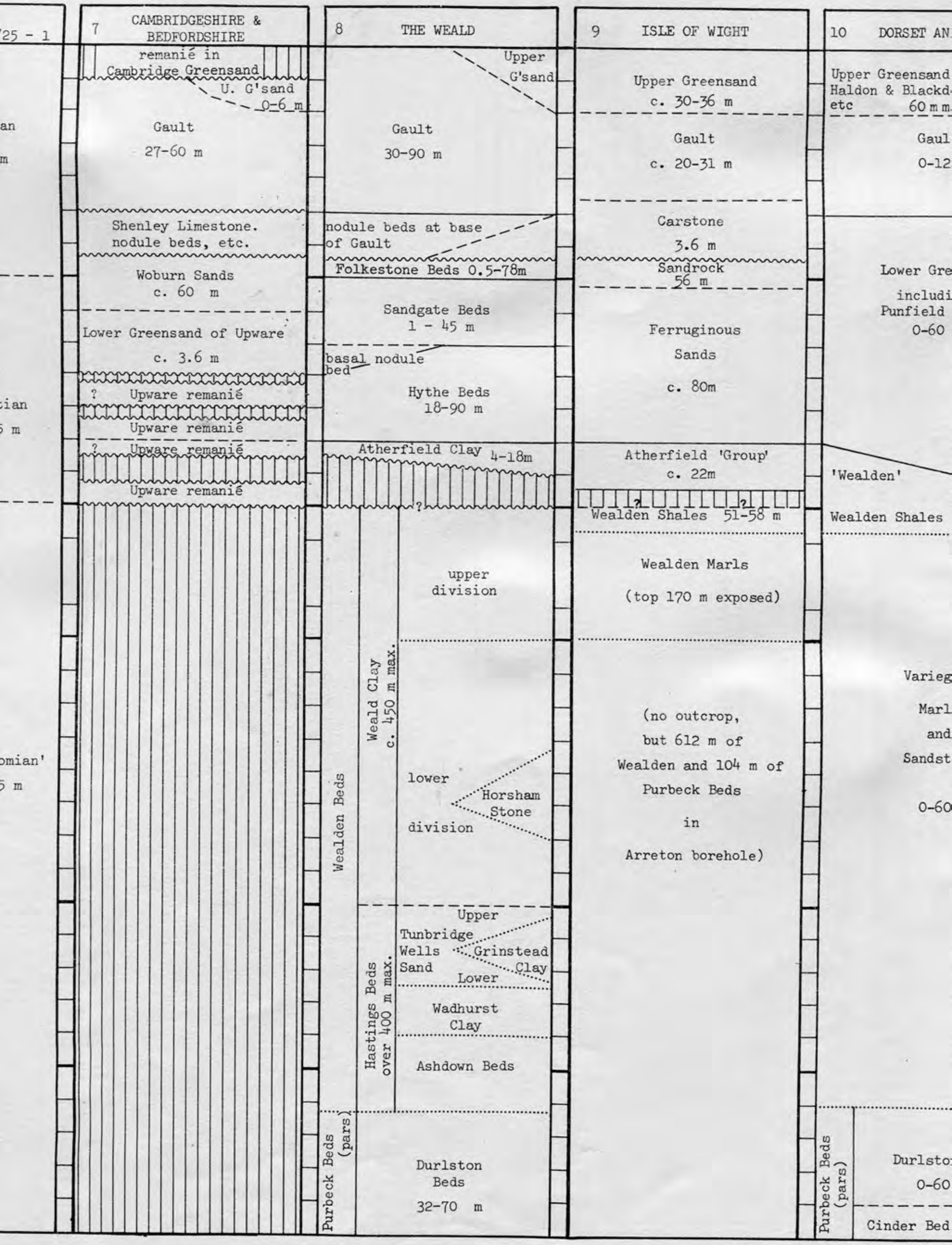


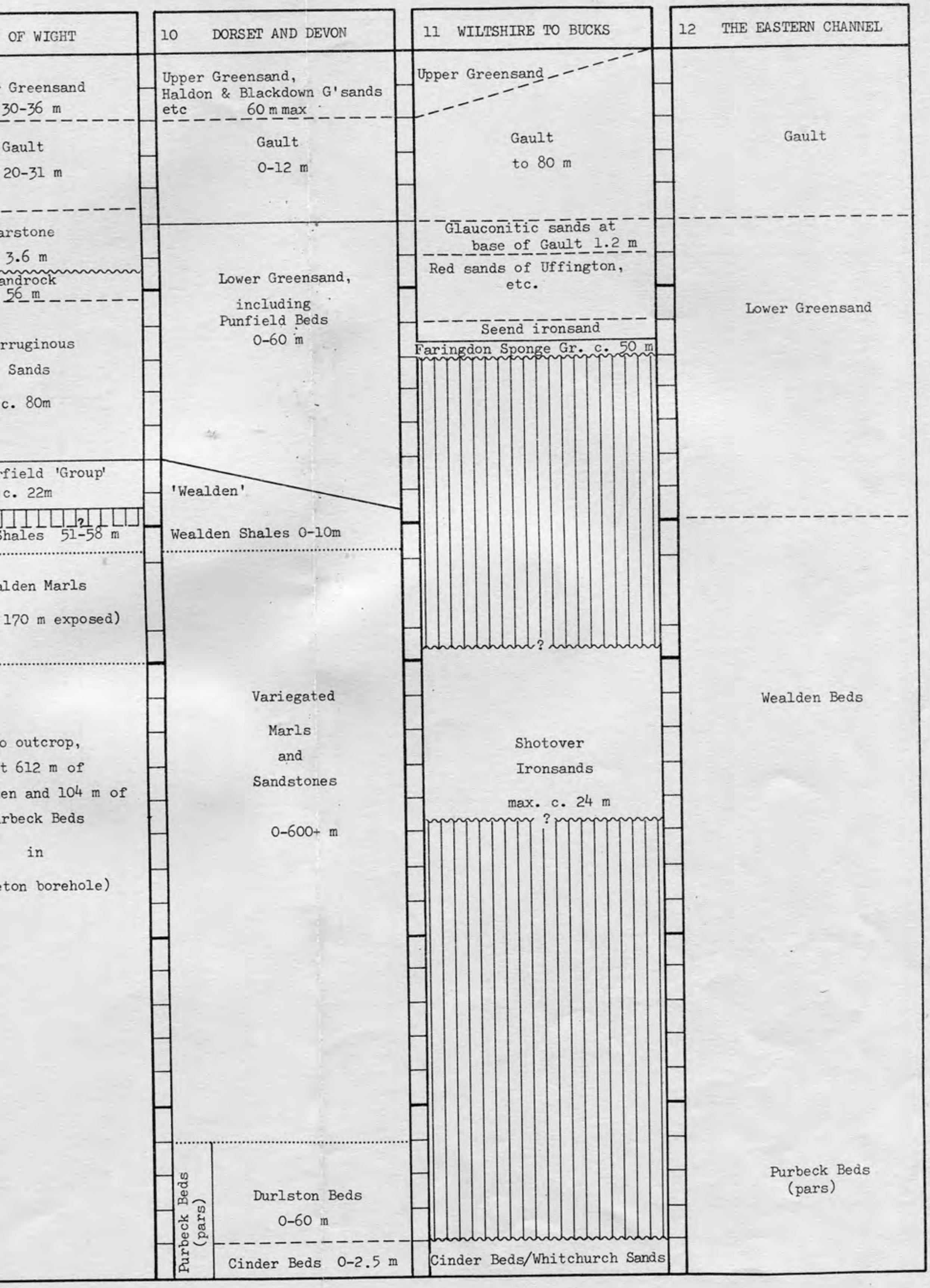
FIG. 5. Cretaceous of the English Channel.

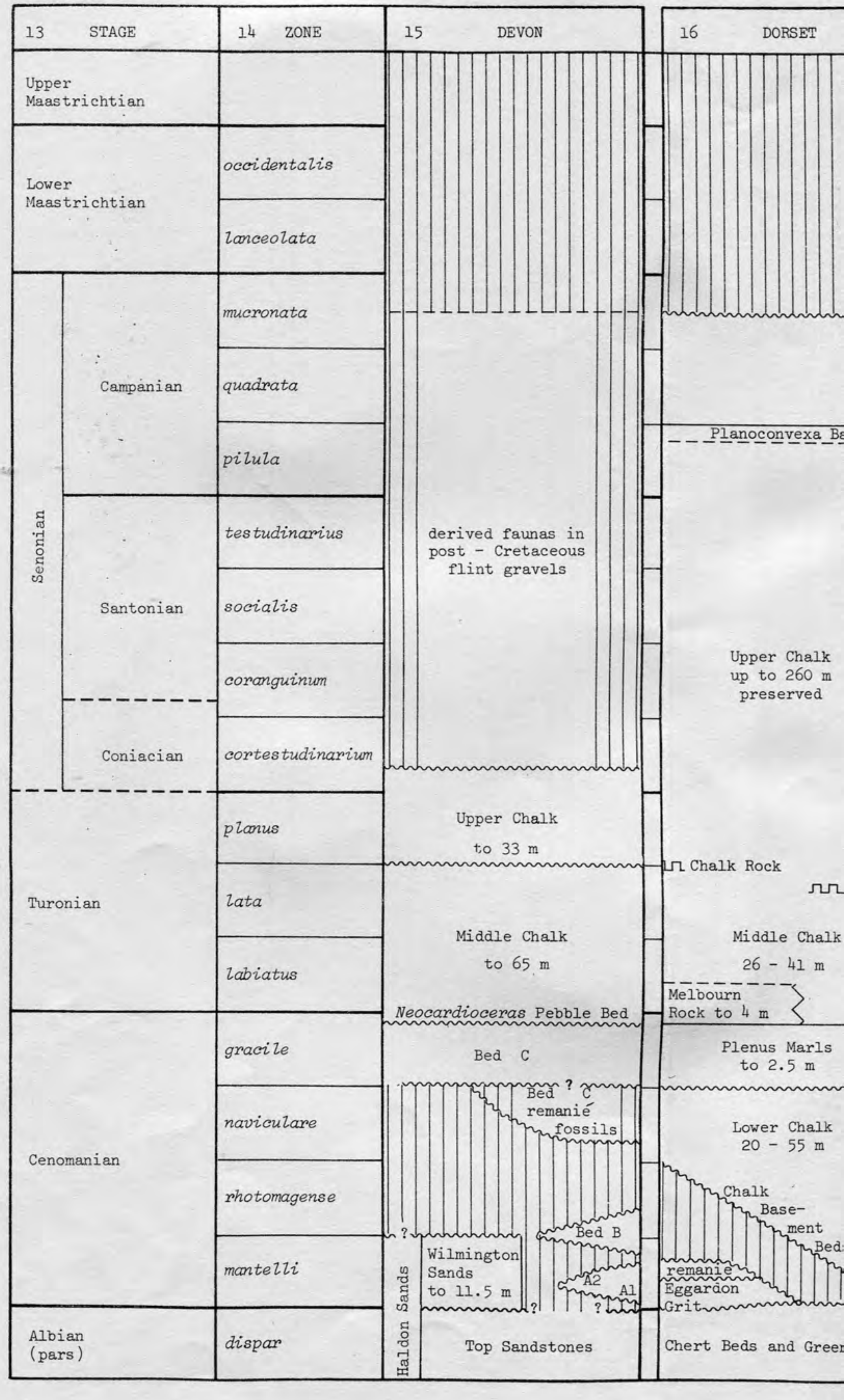
FIG. 3. Correlation of the Lower Cretaceous.

1 STAGE		2 ZONE	3		
ALBIAN	U	*dispar*			
		inflatum	Speeton Clay Formation	A Beds - *Neohibolites*	
	M	*lautus*			
		loricatus			
		dentatus			
	L	*mammillatum*			
		tardefurcata			
APTIAN	U	*jacobi*			
		nutfieldiensis			
		martinioides			
	L	*bowerbanki*			
		deshayesi			
		forbesi			
		fissicostatus		B Beds - *Oxyteuthis*	
BARREMIAN	U	*bidentatum*			
		rude -			
	L	*fissicostatum*			
		rarocinctum			
HAUTERIVIAN	U	*variabilis*		C Beds - *Hibolites*	
		marginatus			C1-
		gottschei			
		speetonensis			C11
	L	*inversus*			
		regale			39 m
		noricum		D Beds - *Acroteuthis*	
		amblygonium			
VALANGINIAN	U	unnamed			D1-
		pitrei			
		Dichotomites			D8
	L	*Polyptychites*			14 m
		Paratollia			
RYAZANIAN	U	*albidum*			
		stenomphalus			
		icenii		E	
	L	*kochi*			
		runctoni			

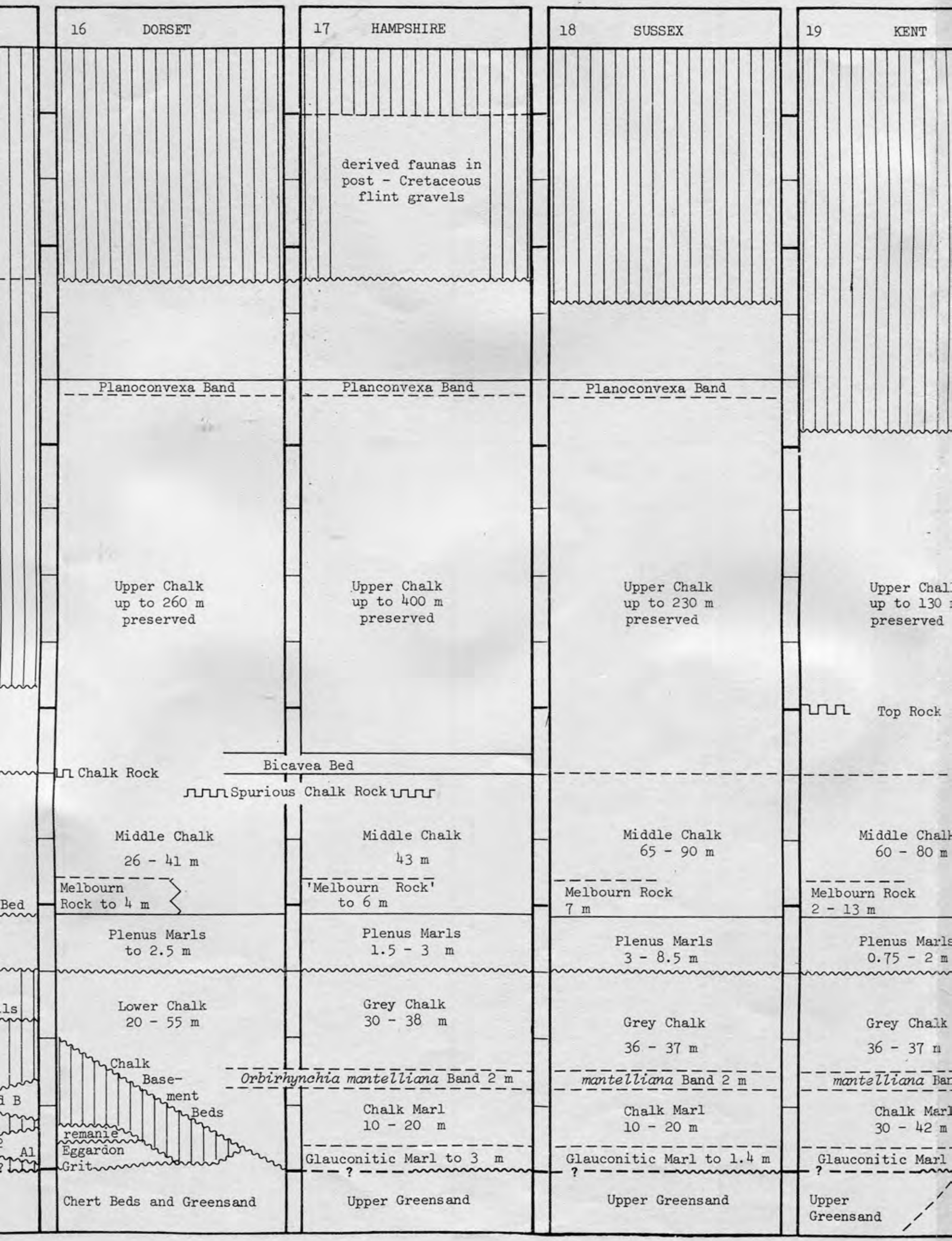

SPEETON
Red Chalk c. 12.5 m
minimus marls c. 6 m
Greensand Streak
ewaldi beds c. 2.8m
Upper B c. 9 m
ement Beds c. 10 m
Lower B 21 m
Simbirskites beds (LB5E - C7)
Endemoceras beds (C8.- D2D)
remanié fauna at base of D2D
lyptych. beds (D2E-D3)
aratollia beds (D4)
(D5)
eregr. beds (D6-D7E)
(D7F - D8)
? ?
Coprolite Bed 0.1m
4 CENTRAL AND SOUTH LINCOLNSHIRE
Red Chalk 1.5 - 7 m
Carstone Grit 2 - 3 m
Carstone Sands & Clays 3 - 4.5 m
Sutterby Marl 2 - 3.5 m
remanié at base of Sutt. Marl
remanié at base of Sutt. Marl
Skegness Clay/Sutt. remanié
Fulletby Beds 10 - 15 m
Upper Tealby Clay 10 - 11 m
Tealby Limestone 2 - 5 m
Lower Tealby Clay 10 - 12 m
Claxby Ironstone 4 - 6 m
Hundleby Clay 0-5 m
Upper Spilsby Sandstone 8 - 11 m
mid-Spilsby nodule bed 0.1 - 0.6 m
5 NORFOLK
Red Chalk 1.3 m
Gault Clay 2 - 18m
Carstone 0 - 18 m
remanié at base of Carstone
remanié at base of Carstone
Fulletby Beds 0-1.5m
Dersingham Beds (with Snettisham Clay facies) 0 - 25 m
Sandringham Sands (pars)
Leziate Beds 0 - 35 m
Mintlyn Beds 0 - 15 m
basal Cretaceous nodule bed 0.1-0.3 m
6 NORTH SEA
48/22 - 2
29/25 - 1
Red Chalk Formation 29 m
Albian 42 m
Aptian 45 m
Speeton Clay Formation 172 m
'Neocomian' 165 m
? ? ? ?
Spilsby Sandstone Formation 24 m
7
L

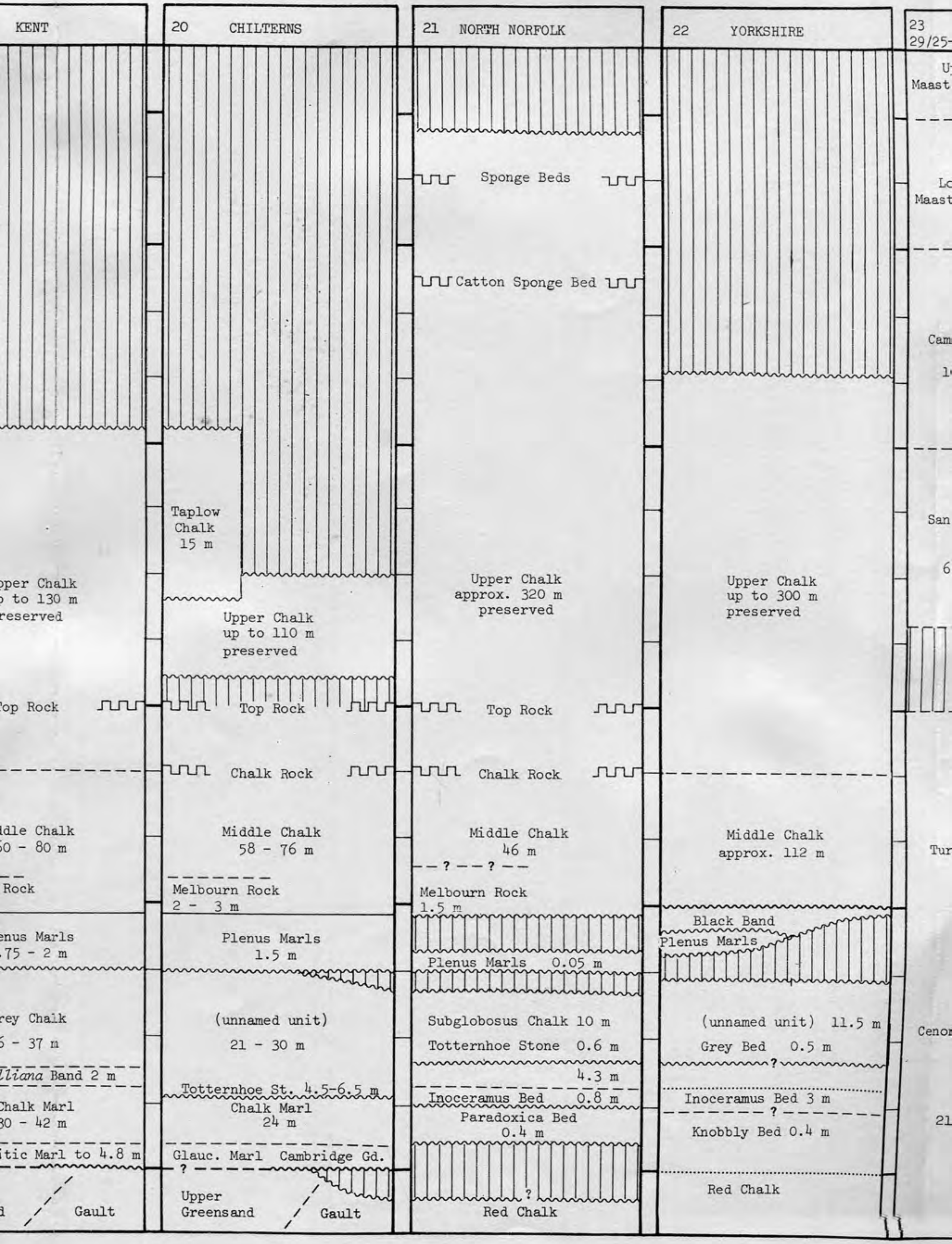

/25 - 1
an
m
tian
5 m
omian'
5 m
7
CAMBRIDGESHIRE & BEDFORDSHIRE
remanié in Cambridge Greensand
U. G'sand 0-6 m
Gault 27-60 m
Shenley Limestone. nodule beds, etc.
Woburn Sands c. 60 m
Lower Greensand of Upware c. 3.6 m
? Upware remanié
Upware remanié
? Upware remanié
Upware remanié
8
THE WEALD
Upper G'sand
Gault 30-90 m
nodule beds at base of Gault
Folkestone Beds 0.5-78m
Sandgate Beds 1 - 45 m
basal nodule bed
Hythe Beds 18-90 m
Atherfield Clay 4-18m
?
upper division
Weald Clay c. 450 m max.
lower division
Horsham Stone
Wealden Beds
Upper
Tunbridge Wells Sand
Grinstead Clay
Lower
Wadhurst Clay
Ashdown Beds
Hastings Beds over 400 m max.
Purbeck Beds (pars)
Durlston Beds 32-70 m
9
ISLE OF WIGHT
Upper Greensand c. 30-36 m
Gault c. 20-31 m
Carstone 3.6 m
Sandrock 56 m
Ferruginous Sands c. 80m
Atherfield 'Group' c. 22m
?
?
Wealden Shales 51-58 m
Wealden Marls (top 170 m exposed)
(no outcrop, but 612 m of Wealden and 104 m of Purbeck Beds in Arreton borehole)
10
DORSET AN
Upper Greensand Haldon & Blackd etc 60 m m.
Gaul 0-12
Lower Gre includi Punfield 0-60
'Wealden'
Wealden Shales
Varieg Marl and Sandst 0-60
Purbeck Beds (pars)
Durlsto 0-60
Cinder Bed

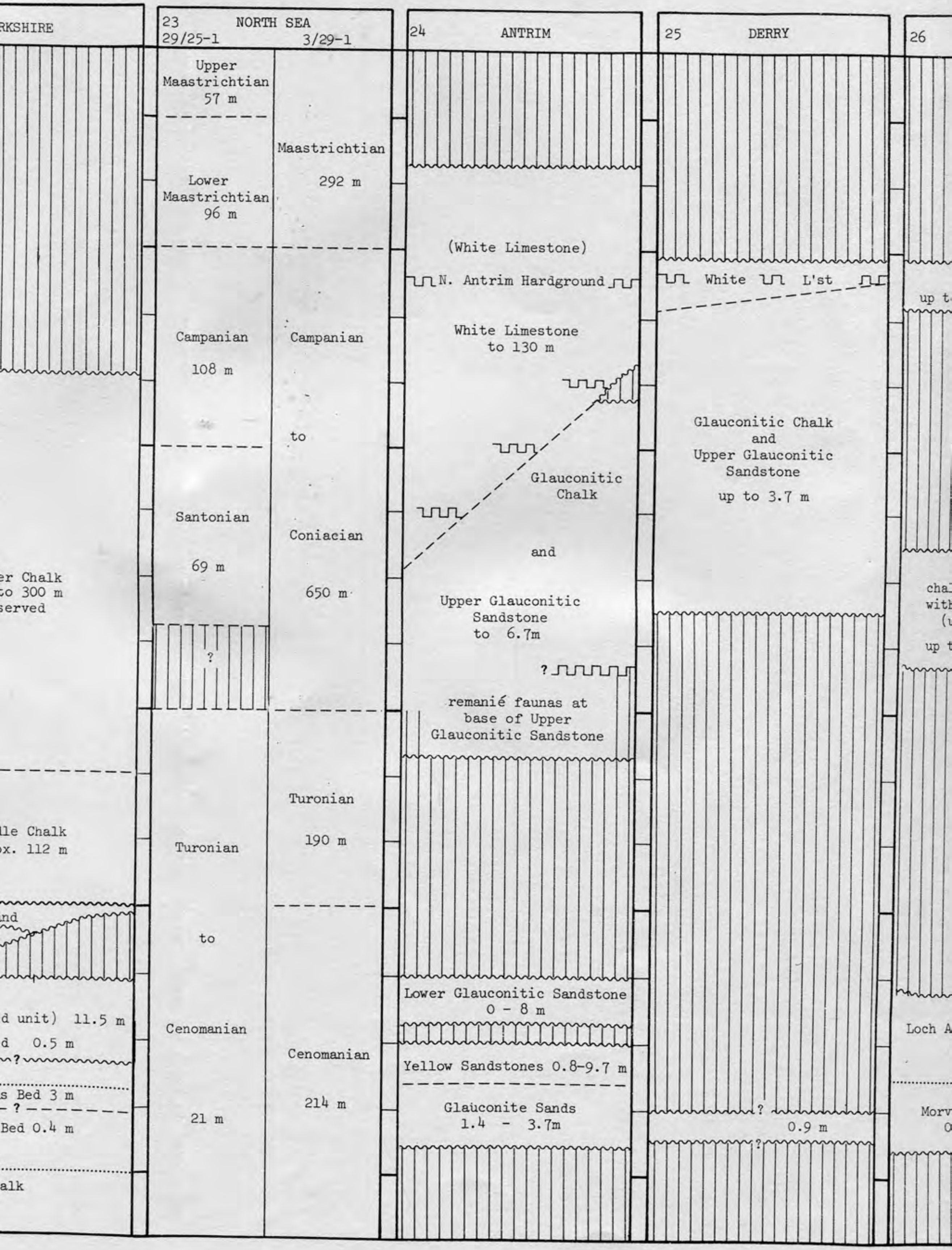

OF WIGHT
Greensand
30-36 m
Gault
20-31 m
arstone
3.6 m
androck
56 m
rruginous
Sands
c. 80m
field 'Group'
c. 22m
?
Shales 51-58 m
lden Marls
170 m exposed)
o outcrop,
t 612 m of
en and 104 m of
rbeck Beds
in
ton borehole)
10 DORSET AND DEVON
Upper Greensand,
Haldon & Blackdown G'sands
etc 60 m max
Gault
0-12 m
Lower Greensand,
including
Punfield Beds
0-60 m
'Wealden'
Wealden Shales 0-10m
Variegated
Marls
and
Sandstones
0-600+ m
Purbeck Beds
(pars)
Durlston Beds
0-60 m
Cinder Beds 0-2.5 m
11 WILTSHIRE TO BUCKS
Upper Greensand
Gault
to 80 m
Glauconitic sands at
base of Gault 1.2 m
Red sands of Uffington,
etc.
Seend ironsand
Faringdon Sponge Gr. c. 50 m
?
Shotover
Ironsands
max. c. 24 m
?
Cinder Beds/Whitchurch Sands
12 THE EASTERN CHANNEL
Gault
Lower Greensand
Wealden Beds
Purbeck Beds
(pars)



13 STAGE	14 ZONE	15 DEVON	16 DORSET
Upper Maastrichtian			
Lower Maastrichtian	*occidentalis*		
	lanceolata		
Senonian Campanian	*mucronata*	derived faunas in post - Cretaceous flint gravels	
	quadrata		
	pilula		Planoconvexa Ba
Santonian	*testudinarius*		Upper Chalk up to 260 m preserved
	socialis		
	coranguinum		
Coniacian	*cortestudinarium*		
Turonian	*planus*	Upper Chalk to 33 m	Chalk Rock
	lata	Middle Chalk to 65 m	Middle Chalk 26 - 41 m
	labiatus	*Neocardioceras* Pebble Bed	Melbourn Rock to 4 m
Cenomanian	*gracile*	Bed C	Plenus Marls to 2.5 m
	naviculare	? Bed C remanié fossils	Lower Chalk 20 - 55 m
	rhotomagense	? Bed B	Chalk Basement Bed
	mantelli	Haldon Sands Wilmington Sands to 11.5 m ? A2 A1 ?	remanié Eggardon Grit
Albian (pars)	*dispar*	Top Sandstones	Chert Beds and Gree


Bed
ls
d B
Al
16 DORSET
Planoconvexa Band
Upper Chalk up to 260 m preserved
Chalk Rock
Middle Chalk 26 - 41 m
Melbourn Rock to 4 m
Plenus Marls to 2.5 m
Lower Chalk 20 - 55 m
Chalk Basement Beds
remanié
Eggardon Grit
Chert Beds and Greensand
17 HAMPSHIRE
derived faunas in post - Cretaceous flint gravels
Planconvexa Band
Upper Chalk up to 400 m preserved
Bicavea Bed
Spurious Chalk Rock
Middle Chalk 43 m
'Melbourn Rock' to 6 m
Plenus Marls 1.5 - 3 m
Grey Chalk 30 - 38 m
Orbirhynchia mantelliana Band 2 m
Chalk Marl 10 - 20 m
Glauconitic Marl to 3 m
?
Upper Greensand
18 SUSSEX
Planoconvexa Band
Upper Chalk up to 230 m preserved
Middle Chalk 65 - 90 m
Melbourn Rock 7 m
Plenus Marls 3 - 8.5 m
Grey Chalk 36 - 37 m
mantelliana Band 2 m
Chalk Marl 10 - 20 m
Glauconitic Marl to 1.4 m
?
Upper Greensand
19 KENT
Upper Chal
up to 130
preserved
Top Rock
Middle Chalk
60 - 80 m
Melbourn Rock 2 - 13 m
Plenus Marls
0.75 - 2 m
Grey Chalk 36 - 37 m
mantelliana Ban
Chalk Marl 30 - 42 m
Glauconitic Marl
?
Upper Greensand


KENT
pper Chalk
o to 130 m
reserved
Top Rock
ddle Chalk
50 - 80 m
Rock
enus Marls
.75 - 2 m
rey Chalk
5 - 37 m
lliana Band 2 m
Chalk Marl
30 - 42 m
itic Marl to 4.8 m
d
Gault
20 CHILTERNS
Taplow
Chalk
15 m
Upper Chalk
up to 110 m
preserved
Top Rock
Chalk Rock
Middle Chalk
58 - 76 m
Melbourn Rock
2 - 3 m
Plenus Marls
1.5 m
(unnamed unit)
21 - 30 m
Totternhoe St. 4.5-6.5 m
Chalk Marl
24 m
Glauc. Marl
Cambridge Gd.
?
Upper
Greensand
Gault
21 NORTH NORFOLK
Sponge Beds
Catton Sponge Bed
Upper Chalk
approx. 320 m
preserved
Top Rock
Chalk Rock
Middle Chalk
46 m
? ?
Melbourn Rock
1.5 m
Plenus Marls 0.05 m
Subglobosus Chalk 10 m
Totternhoe Stone 0.6 m
4.3 m
Inoceramus Bed 0.8 m
Paradoxica Bed
0.4 m
?
Red Chalk
22 YORKSHIRE
Upper Chalk
up to 300 m
preserved
Middle Chalk
approx. 112 m
Black Band
Plenus Marls
(unnamed unit) 11.5 m
Grey Bed 0.5 m
?
Inoceramus Bed 3 m
?
Knobbly Bed 0.4 m
Red Chalk
23
29/25-
U
Maast
Lo
Maast
Cam
1
San
6
Tur
Cenor
21


RKSHIRE
er Chalk
to 300 m
served
lle Chalk
ox. 112 m
nd
d unit) 11.5 m
d 0.5 m
?
s Bed 3 m
?
Bed 0.4 m
alk
23 NORTH SEA
29/25-1
3/29-1
Upper
Maastrichtian
57 m
Lower
Maastrichtian
96 m
Campanian
108 m
Santonian
69 m
?
Turonian
to
Cenomanian
21 m
Maastrichtian
292 m
Campanian
to
Coniacian
650 m
Turonian
190 m
Cenomanian
214 m
24 ANTRIM
(White Limestone)
N. Antrim Hardground
White Limestone
to 130 m
Glauconitic
Chalk
and
Upper Glauconitic
Sandstone
to 6.7m
?
remanié faunas at
base of Upper
Glauconitic Sandstone
Lower Glauconitic Sandstone
0 - 8 m
Yellow Sandstones 0.8-9.7 m
Glauconite Sands
1.4 - 3.7m
25 DERRY
White L'st
Glauconitic Chalk
and
Upper Glauconitic
Sandstone
up to 3.7 m
?
0.9 m
?
26
up t
chal
with
(u
up t
Loch A
Morv
O

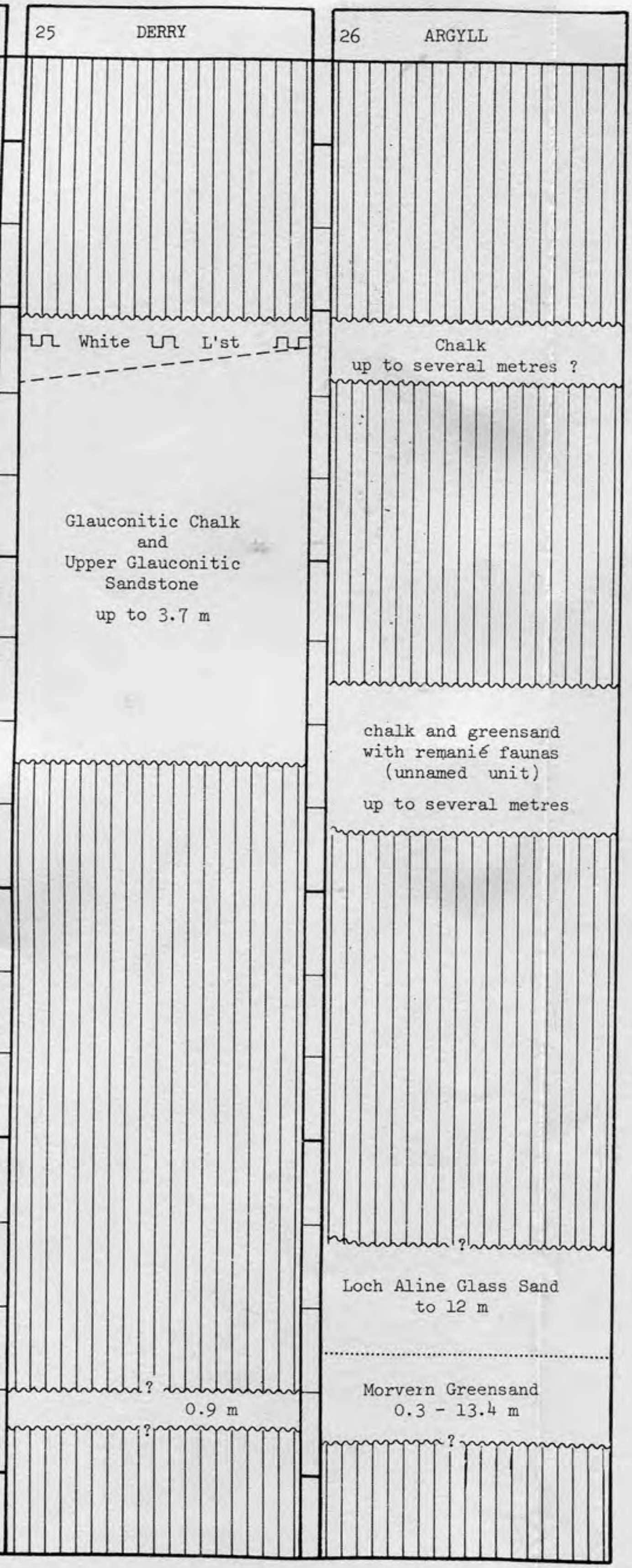


FIG. 6. Correlation of the Upper Cretaceous.

In the chart, the number of zones is limited to those which can be recognized throughout the British Isles. Subzones can be recognized, especially in southern England. The zones are not equal in thickness or duration. Thus each of the zones of the Campanian was longer than the whole of the Turonian age. The single word name of each zone is that currently used, but the *socialis* and *testudinarius* Zones are also commonly referred to by the generic names of their index species, namely *Uintacrinus* and *Marsupites* Zones.

Disconformities are indicated by wavy horizontal lines, and hard-grounds by castellated lines. Many, possibly all, disconformities and hard-grounds involve condensation and/or a break in sedimentation, but vertical shading is used only where palaeontological evidence indicates absence of sediment. Nearly all the units within the columns are lithological, but occasionally we have inserted divisions based on the abundance of a particular fossil, e.g. *Mantelliana* Band.

Further still to the south-west, in the region north-west and west of Finistère, a number of small, mostly fault-bounded, inliers have been located. Lower Cretaceous beds are thus apparently absent in the area between the Palaeozoic massifs of Cornubia and the Cotentin.

In the eastern Channel there is, no doubt, a complete succession of Lower Cretaceous beds in the area between the Weald and the Boulonnais (Lapierre 1975). Few samples have been taken owing to the cover of superficials, but samples include rocks of types characteristic of the Purbeck, Wealden, Lower Greensand and Gault of the Weald. In the anticlines south of the Isle of Wight and north of 50° 12′ N (Dingwall 1971) thick Wealden deposits are proved by cores and continuous seismic profile (CSP) records, and one sample of Lower Greensand has been taken. Gault has not been recovered in this area but may be present as it is known to the south-east at about 50° 02′ N.

Deposits in the inliers off Finistère have yielded palynomorphs suggesting a Wealden age. The more westerly inliers include glauconitic beds which are presumably marine (Barthe *et al.* 1967); however, in the large inlier to the east (Curry *et al.* 1970) only rocks of continental aspect have been reported.

7. CORRELATION OF THE UPPER CRETACEOUS (FIGURE 6, COLUMNS 15–26)

The English Channel

The Upper Cretaceous is very widespread and almost always in chalk facies, but includes glauconite and sandy beds locally at the base. Micropalaeontological examination (of about 150 core samples) combined with continuous seismic profiling has provided a rather detailed picture of the pattern of Cretaceous stages present and the total thickness in various areas (Curry *et al.* 1965, 1970; Andreieff *et al.* 1975; Curry & Smith 1975) (Fig. 5). A maximum thickness of about 450 m has been reported half way between the Isle of Wight and Cherbourg and also 80 km south-south-west of Plymouth. 200 m is present south of Start Point and no more than 140 m in profiles between Start Point and Guernsey. In the eastern Channel, 350 m is recorded south of Beachy Head, reducing to 250 m near Le Touquet. Carter & Destombes (1972) reported on samples from exploratory bores for the Channel tunnel but otherwise little stratigraphical detail is available from the area. The thicknesses deduced from CSP records suggest that the sequences present are similar to those on nearby land and the few rock samples examined are consistent with this idea. To the south of the Isle of Wight, Dingwall (1971) recorded a representation of all the Upper Cretaceous stages, noting that Maastrichtian occurrences appeared to be confined to the region south of 50°15′N. In this region Cenomanian beds are distinctive on CSP records; this is linked to the presence of rocks in Upper Greensand facies. Immediately north of the Cotentin peninsula and also on the submerged basement to the west, only Upper Campanian or Maastrichtian rocks have been recorded, resting directly on early Mesozoic or basement (Bignot & Larsonneur 1969; Groupe Norois 1972). Andreieff *et al.* (1975) reported on the area between Cherbourg, Start Point and the coast of northern Brittany. South and east of Start Point the Upper Cretaceous begins with glauconitic calcareous sandstones. These have yielded *Orbitolina* of Cenomanian age. Overlying beds range at least up to the Campanian, although Turonian has not yet been proved. Further to the south, in the region of the Hurd Deep, neither Cenomanian nor Turonian rocks have been proved. The oldest samples recorded are glauconitic chalks, which are Coniacian west of Guernsey and north of Lannion, and Santonian or Campanian south-west of Alderney, with a chalk succession up to Maastrichtian. South of Plymouth, Curry, Hersey *et al.* (1965) recorded Cenomanian and Coniacian (but not Turonian) samples in a sequence with a minimum thickness of 25 m. Thicknesses of overlying stages were estimated as: Santonian 50 m, Campanian 110 m, Lower Maastrichtian 110 m, Upper Maastrichtian 60 m. The last is overlain (apparently conformably) by 110 m of Danian. Westwards the Danian and higher Upper Cretaceous beds have been removed progressively by the sub-Eocene unconformity and south-west of the Scillies the Eocene apparently rests on Santonian. Between the Scillies and Haig Fras, grey Cenomanian and white Turonian and Coniacian chalks are well developed (Smith *et al.* 1965).

Devon (Column 15)

The Devon Cenomanian occurs as several dissimilar lithologies in a series of scattered outliers, and includes the most marginal Upper Cretaceous facies represented in England. Hamblin & Wood (1976, with review of earlier literature) demonstrated on ammonite evidence that the topmost member (Cullum Sands with Cherts) of their Haldon Sands Formation (*see* p. 42) is early Cenomanian, this dating presumably applying also to highly fossiliferous devitrified cherts occurring as cobbles in the post-Cretaceous Aller Gravels around Kingskerswell. These have yielded a well-preserved molluscan fauna incorrectly attributed to 'Haldon' in museum collections (*see also* Selwood *et al.*, in press). We believe that the assignment of an early Cenomanian age to the orbitoline limestones of Wolborough by Hart (1971) is erroneous (*see* Hamblin & Wood 1976).

The controversial dating of the whole of the Chert Beds and Top Sandstones of the east Devon coastal sections as Cenomanian on the basis of orbitoline and other foraminiferal evidence (Hart 1973b; Carter & Hart, in press) has been refuted by the discovery of an indigenous late Albian (*dispar* Zone) ammonite fauna close to the junction of the Chert Beds and Top Sandstones near Shapwick Grange Farm near Lyme Regis (Hamblin & Wood 1976: see also p. 42). However, the possibility still exists that the upper part of the Top Sandstones further west may be Cenomanian. In the Beer district, there are early Cenomanian chalky fissure deposits within the Top Sandstones below Bed A (Ali 1975).

The ages of the Wilmington Sands and Cenomanian Limestones are fully documented by Kennedy (1970, with references). No thicknesses are given for subdivisions A_1 and A_2, because wherever they each exceed about 2 m the division between them becomes vague. Smith (1961, p. 96) hazarded a maximum thickness of 5·5 m for A_1 and A_2 combined, but as division A thickens, the proportion of carbonate decreases and it passes laterally into the Wilmington Sands.

At Furley (Kennedy 1970, p. 654) the Chalk Basement Bed yields Lower and Middle Cenomanian fossils and is overlain by glauconitic chalk with remanié *naviculare* Zone and indigenous *gracile* Zone faunas. The succeeding chalk extends up into the Turonian. The microfauna of this succession has been described by Hart (1975).

The *Neocardioceras* Pebble Bed at the base of the Middle Chalk contains remanié ammonites from the upper part of the *gracile* Zone and indigenous basal *labiatus* Zone fossils; the remainder of the Turonian part of the column is based on the work of Jukes-Browne & Hill (1903), Rowe (1903) and new observations. The base of the Middle Chalk varies in age along the Devon coast, and horizons well up into the *lata* Zone rest on the Cenomanian Limestone in Hooken Cliff, west of Beer (Smith 1961).

The thickness and extent of the Devon Senonian is taken from Rowe (1903), although it should be noted that these measurements are estimates, except where he gave detail of specific sections. Bailey (1975) has demonstrated a significant microfaunal change in the Annis Knob succession which he took to mark the Turonian–Coniacian boundary (*see* p. 26).

Previous workers noted that although the highest *in situ* chalk fell within the *cortestudinarium* Zone, derived fossils preserved in flints from high level gravels indicated the former presence of higher zones (Rowe 1903; Jukes-Browne 1902; Jukes-Browne & Hill 1904). Flint fossils in the Haldon Gravels (Wood *in* Selwood *et al.*, in press) provide definite evidence of the *cortestudinarium* Zone to the upper third of the *quadrata* Zone, and limited and equivocal evidence for high *planus* Zone and low *mucronata* Zone in the source area of these gravels. The various echinoid and brachiopod assemblages parallel those known from the Chalk of Hampshire. Similar derived flint fossils are found in the Orleigh Court gravels near Buckland Brewer, north Devon (Rogers & Simpson 1937), and as isolated records in Cornwall. It is noteworthy that there is no evidence for the former presence of Lower and Middle Turonian in the Dartmoor area. There is evidence that such a break may occur in the Western Approaches succession, which suggests that these successions reflect a Turonian regressive phase.

Dorset (Column 16)

The Cenomanian succession in Dorset has been extensively documented by Kennedy (1970). In the north of the county there may be a continuous passage from Albian to Cenomanian locally, whilst south-west of the line of the Frome Valley, there is Cenomanian Upper Greensand in the form of the Eggardon Grit. The age of the base of this unit is not known, but on regional grounds it is probably close to, if not at, the Albian/Cenomanian boundary.

Above, the base of the Lower Chalk is diachronous ranging from low in the *mantelli* Zone in a Glauconitic Marl facies in the north to a low *naviculare* Zone Basement Bed facies in the south-west. Full details of the Plenus Marls succession were given by Jefferies (1962, 1963). The top part of the *gracile* Zone is represented within the basal part of the Middle Chalk.

The Turonian succession is based on the work of Rowe (1902), Jukes-Browne and Hill (1903, 1904), White (1923), Wright *in* Arkell (1947) and Wilson *et al.* (1958). The only measurements of zonal thicknesses are those by Rowe on the coastal sections (1902, p. 42–43) and he remarked on the difficulty of getting them with any degree of accuracy. White (1923) estimated for north-east Dorset that the *labiatus* Zone was 11–12 m, the *lata* Zone 18–20 m and the *planus* Zone about 6·5 m. The Melbourn Rock is not developed as a distinct bed in south Dorset, but there are repeated bands of nodular chalk. It may be up to 3–4 m thick in north Dorset (White 1923).

The most detailed study of the Senonian Chalk succession is by Rowe (1902), but because of the comparative inaccessibility of many of the sections, and the degree to which the chalk has suffered tectonic disturbance, he was able to establish little more than a broad zonal outline. Brydone (1914) re-examined several of Rowe's sections in the broad '*Actinocamax quadratus*' Zone, and successfully demonstrated the occurrence of his various subdivisions of the *pilula* Zone. The restricted *quadrata* Zone has not been studied in detail. A short account of the Dorset Senonian was given by Wright *in* Arkell (1947). The highest *in situ* chalk is seen in the cliffs at Studland, and is equivalent to the lower third of the Weybourne Chalk of Norfolk (N. B. Peake, personal communication). This indicates that the highest chalk here is still below the middle of the *mucronata* Zone.

The high-level (Bagshot?) gravels at Bincombe, south of Dorchester, contain blocks of white siliceous rocks with a rich brachiopod fauna preserved as moulds (Fisher 1896), which includes both Upper Campanian and probable Maastrichtian elements of possibly extra-British provenance. Comparable faunas occur in the high-level gravels of the Isle of Wight (*see* p. 49).

Hampshire (Column 17)

This column is based chiefly on the coastal exposures in the Isle of Wight.

The Cenomanian Lower Chalk has been extensively described by Kennedy (1970) and the Plenus Marls by Jefferies (1962, 1963). On the island their combined thickness varies from 50 to 62 m, but at Portsdown, Taitt & Kent (1958) record over 100 m of Lower Chalk. The base of the Cenomanian is variable, locally disconformable, but in places there may be a passage from the preceding Albian Upper Greensand. Possibly there are thin local developments of Cenomanian Upper Greensand. The Cenomanian/Turonian boundary lies low within the Middle Chalk, but the precise position of the base of the *labiatus* Zone is not known. The Melbourn Rock is poorly developed.

The Turonian succession is based on the work of the above authors, and on Brydone (1917) and Middlemiss & Bromley (1963).

The chief accounts of the Senonian of the Isle of Wight are by Jukes-Browne & Hill (1904) and Rowe (1908). Subsequently Brydone (1914, 1918) established the presence of his *pilula* Zone and made critical comments on some of Rowe's zonal attributions of the inland pits in the higher part of the succession. All this work is synthesized competently by White (1921) with additional observations based on White's own fieldwork. Considerable differences exist in the Senonian successions of the two sides of the island. The eastern (Culver) succession is much reduced in thickness and contains numerous hardgrounds and associated green-coated chalk pebbles providing evidence of interrupted sedimentation (Middlemiss & Bromley 1963). Barr (1962) took the Culver Cliff Senonian as a standard in his study of Upper Cretaceous planktonic foraminifera, but unfortunately Barr related his foraminifera to Rowe's zonal divisions, the placing of which is known to be in error for this section (Brydone 1914, 1918).

The succession on the Hampshire mainland is detailed by Brydone (1912, 1914) and the relevant Geological Survey memoirs, horizons up to and including basal *mucronata* Zone being present.

White siliceous rocks from the high level gravels of the Ventnor area yield a fauna of echinoids and brachiopods (preserved as moulds) which includes both Upper Campanian and lower Maastrichtian elements (cf. Devon). Some of the *Echinocorys* suggest an extra-British source (N. B. Peake, personal communication). Comparable siliceous rocks are also found as blocks on the beach at Southbourne near Bournemouth, presumably fallen from the Bagshot gravels; Curry (1964) reported Campanian and Maastrichtian (including Upper Maastrichtian) fossils from rotten flint pebbles in the Boscombe Pebble Beds at this locality.

Sussex (Column 18)

The chalk of Sussex has been classic since Mantell's day (Mantell 1818, 1822, 1827, 1833). The Cenomanian sequence is discussed fully by Kennedy (1969) and Jefferies (1962, 1963). The Lower Chalk varies around 60 m; the Plenus Marls from 4 to 8·5 m. The base of the Cenomanian is variable, and is often a minor disconformity. Hart (in discussion of Kennedy 1969) suggested that much of the Upper Greensand was Cenomanian on the basis of the microfauna. There is no macrofaunal evidence to support this view. As elsewhere, the base of the Middle Chalk is still within the Cenomanian, and the base of the *labiatus* Zone is low within the Melbourn Rock.

The broad outline of the coastal Turonian and Senonian sections was given by Rowe (1900) with further information being provided by Jukes-Browne & Hill (1903), 1904) and White (1924, 1926). The detailed zonal stratigraphy of the post-*Marsupites* Zone chalk was described by Brydone (1914, 1915) and by Gaster (1924, 1925, 1930), who recognized further subdivisions within the *pilula* and *quadrata* Zones. Gaster's later papers (1937, 1939, 1944, 1951) provide zonal maps for the county and catalogues of localities.

The highest chalk exposed in Sussex is seen in intermittent beach exposures at Felpham, near Bognor (Venables 1931, 1932). These extend up to the basal beds of the *mucronata* Zone and include a band of *Echinocorys subconicula* comparable with that found elsewhere at the base of the zone. The foreshore exposures eastwards of Felpham as far as Worthing were zoned by Martin (1932); further notes on these exposures and comments on the equally limited coastal sections in the area of the Portsdown anticline (Hampshire) can be found in Martin (1938).

Kent (Column 19)

The Cenomanian succession in Kent is extensively reviewed by Kennedy (1970), Jefferies (1962, 1963) and Destombes & Shepherd-Thorn (1971). The Lower Chalk varies between 80 m (at the coast) and 60 m; the Plenus Marls are from 0·75 to 2 m thick and up to 3 m of the Melbourn Rock are of Cenomanian age. The basal Cenomanian, the Glauconitic Marl, rests on Gault clay in east Kent, with a minor disconformity. Westwards, Upper Greensand facies appears near Sevenoaks and, locally, there is probably a transition from Albian to Cenomanian, with some Cenomanian Upper Greensand, as in Surrey (Kennedy 1969, p. 489). A variety of lithological divisions have been recognized in the Lower Chalk of the Weald, but all are rather vague. Terms such as Chalk Marl and Grey Chalk are widely used, but the dividing line varies from place to place and author to author. The *Orbirhynchia mantelliana* Band is a key marker horizon of wide geographical extent.

The Turonian and Senonian succession is based chiefly on the classic coastal cliff sections described by Rowe (1900), Jukes-Browne & Hill (1903, 1904), White (1928) and (Peake in Pitcher *et al.* 1967). Inland areas are covered by Jukes-Browne & Hill (1903, 1904) and various Geological Survey Sheet Memoirs. The highest Senonian preserved in Kent—low in the *pilula* Zone—is found at Foreness Point in the Thanet cliffs, inland near Broadstairs, and as derived material in the Clay-with-Flints resting on the Chalk (Peake in Pitcher *et al.* 1967).

The Chilterns and adjacent areas (Column 20)

The Cenomanian sequence is based on the accounts of Jukes-Browne & Hill (1903, with references), Forbes (1960), Burnaby (1962), Jefferies (1962, 1963), Cookson & Hughes (1964) and some new observations. The Lower Chalk varies between 50 and 60 m in thickness. In the south-western Chilterns there is often a complete lithological passage between the Upper Greensand and the glauconitic base of the Lower Chalk, sometimes with and sometimes without phosphatic nodules; it is uncertain whether there is a non-sequence within this succession. In the northern Chilterns, around Dunstable, there is a small area over which the Gault passes up into Chalk Marl, but from Harlington (10 km northwest of Luton) to the Cambridgeshire Fens the Gault is disconformably capped by a distinct basement bed to the Chalk Marl. This is the Cambridge Greensand, a glauconitic marl packed with phosphatic nodules, chiefly late Albian, derived from the underlying Gault (Casey *in* Edmonds & Dinham 1965). The Cambridge Greensand was deposited during the early Cenomanian since it has yielded *Schloenbachia* cf. *varians subplana* (Cookson & Hughes 1964) (although Casey *in* Edmonds & Dinham 1965, p. 55, has questioned the provenance of this ammonite); 5 species of benthonic foraminifera and 2 species of planktonic forms give an unequivocal Cenomanian age (Hart 1973a).

The base of the Totternhoe Stone yields both phosphatized and unphosphatized *rhotomagense* Zone fossils, and the base of this zone appears to be at or a little below the bottom of the Totternhoe Stone. *Naviculare* Zone ammonites occur up to 10 m below the Plenus Marls. Full details of the marls were given by Jefferies (1962, 1963). The Cenomanian/Turonian boundary is somewhere above the base of the Melbourn Rock.

Little is known of the pre-*planus* Zone Turonian; the sequence is taken from Jukes-Browne & Hill (1903), Chatwin & Withers (1908) and White (1932). The base of the *planus* Zone is conventionally taken at the lithological change marked by the base of the Chalk Rock (a 3–4 m complex of mature and strongly mineralized hardgrounds: Bromley 1965, 1967; Kennedy & Garrison 1975), but this is extremely difficult to apply with consistency because in some sections the top of the *lata* Zone contains nodular chalks and incipient hardgrounds with rare aragonitic fossils. In north Hertfordshire the Chalk Rock ceases to be a distinct rock band and becomes a nodular chalk. Aragonitic fossils occur sparingly throughout the Chalk Rock complex, but the classic *Hyphantoceras reussianum* fauna described by Woods (1896, 1897), Billinghurst (1927) and Wright (in press) is best developed in the terminal hardground. The upper limit of the *planus* Zone is taken at the Top Rock which is a thin, mature hardground with associated glauconitized pebbles.

The Top Rock is succeeded by an unknown thickness of chalk referred to the *cortestudinarium* Zone, which has very few hardgrounds or nodular chalk horizons compared with elsewhere in southern England. The lowest *Micraster* in this zone in the Chilterns are already typical of those in the upper part of the *cortestudinarium* Zone in east Kent, and *Micraster normanniae* is absent: the Top Rock marks a break where the lower half of the *cortestudinarium* Zone (and possibly the top part of the *planus* Zone) is missing (Stokes 1975).

The highest chalk below the Tertiary Reading Beds is normally in the *coranguinum* Zone, although higher beds are preserved locally, particularly in the western part of the London Basin (White & Treacher 1905). In the Taplow area, near Reading, the top of the *coranguinum* Zone to the base of the *pilula* Zone (*depressula* Subzone) is developed as a fine grained calcarenite packed with phosphate granules (Strahan 1891; White & Treacher 1905; Willcox 1953). A comparable development of phosphatic chalk is found in the *testudinarius* and *pilula* Chalk of the Winterbourne area near Newbury, Berkshire (Treacher & White 1906; White 1907).

Norfolk (Column 21)

The Norfolk chalk falls partly within the loosely defined 'northern subprovince' of the western European Upper Cretaceous, and there are obvious faunal and lithological differences from areas previously described. Ammonites are scarcer in the lower parts of the sequence, and the lowest Cenomanian is very poor in fossils.

The Cenomanian succession in column 21 is for the Hunstanton district, where there are good coastal exposures of the lower part of the sequence, and is based on Peake & Hancock (1961, 1970, with bibliography). Away from the coast, the Lower Chalk expands from only 18 m to 29 m at Marham and 41 m at Stoke Ferry. The dating of the various subdivisions is based upon the very limited ammonite faunas documented by Peake & Hancock, and more recent finds. Details of the Plenus Marls are in Jefferies (1962, 1963) and Peake & Hancock (1970). The position of the base of the Turonian is not accurately known, although it is somewhere above the base of the Middle Chalk.

The Turonian sequence in north Norfolk is very poorly known, but some details are published (Peake & Hancock 1970, pp. 304–9, 339b). The stratigraphy in the Thetford area to the south is given in Hewitt (1924, 1935) and Ward *et al.* (1968, Fig. 3). In contrast with other areas, the study of the post-Turonian succession is complicated by the absence of continuous cliff sections, the limited exposure afforded by the few pits still extant, and the scarcity of fossils in some of the Lower–Middle Senonian. In the higher parts of the succession the chalk is relatively soft, and has been subjected to post-depositional solution and deformation during the Pleistocene, in many cases to such a degree that it is not certain whether a particular exposure can be regarded as part of the *in situ* succession. In fact, some of the smaller pits in the *quadrata* and *mucronata* Zones expose what in fact is virtually reconstituted chalk, with only the contorted flint courses remaining to give some indication of the original bedding. The Maastrichtian successions are known only from huge overfolded masses within the Drift, exposed where they are truncated by the present cliff line and beach platform.

The Senonian and Maastrichtian sequence is based on Peake & Hancock (1961, 1970) which summarizes earlier work. Further details of extant sections in the Norwich area, with discussion of the biostratigraphy of the *mucronata* Zone, are in the Institute of Geological Sciences 1″ Sheet 161 (Norwich) Memoir (Wood, in preparation). The origin and stratigraphical distribution of the potstone (paramoudra) flints is discussed by Bromley *et al.* (1975). A rather detailed sequence has been proposed for the Upper Campanian and Maastrichtian, both autochthonous and allochthonous (*see* Peake & Hancock 1961, 1970).

The *mucronata* Zone extends far higher than in the Hampshire Basin, and is approximately co-extensive with the classic 'Norwich Chalk' of earlier workers. The relation between the Upper Campanian 'Norwich Chalk' and the Lower Maastrichtian 'Trimingham Chalk' is unclear: there is apparently an unexposed sequence spanning the gap between the *in situ* Campanian and the glacially transported Maastrichtian. This point is discussed in detail by Wood (1967) and Peake & Hancock (1970). The highest Chalk seen so far—the Grey Beds subdivision of the Trimingham Chalk—appears to fall within the *occidentalis* Zone of the Lower Maastrichtian, although there is Upper Maastrichtian in the North Sea successions. The occurrence of *Trigonosemus pulchellus* in the Grey Beds would suggest that the highest chalk can be referred to Zone 5 of Surlyk's (1970) zonation of the north-west European Maastrichtian.

Supplementary note on the Suffolk Chalk: The Chalk of this area is comparatively poorly known: the main references are Jukes-Browne (1903), Boswell (1927), Brydone (1932a, 1932b), Gaster (1941) and Markham (1967). It should be noted that all chalk referred to the *mucronata* Zone by early workers is of *quadrata* Zone age, and that there is no *mucronata* Zone chalk known from surface exposures.

Yorkshire (Column 22)

The sequence given here is based chiefly on the succession at South Cave given by Hill (1888), where the Lower Chalk is about 23 m thick; at the coast it thickens to over 40 m. Some section details are given by Jeans (1973). Inland, the Cenomanian begins with the Knobbly Bed (bed 1 of Wright & Wright 1942) which rests on Albian Red Chalk. On the coast at Speeton, the boundary lies within, or at the top of, the 'Grey Band' (Bed V of Wright 1955 *in* Swinnerton 1936–55) which separates a red chalk of Cenomanian age (Wright's 'Upper Red Chalk') from a thick underlying development of Albian Red Chalk (Wright's 'Lower Red Chalk', etc.). The nomenclature of these red beds varies from author to author, but we follow Jukes-Browne & Hill (1903) in using 'Red Chalk' as a formal name for the lower bed and regarding the upper one as a red bed within the Lower Chalk.

The dating of the sequence below the Grey Bed on column 22 is largely guesswork, but some correlation with southern England is possible by means of *Orbirhynchia* (Jeans 1968, Fig. 4). The Grey Bed itself yields *Acanthoceras* gr. *rhotomagense*. The dating of the Black Band is uncertain but the *gracile* Zone is almost certainly incomplete (Jefferies 1963). The Turonian sequence is based on Rowe (1904). Other information was given by Wright & Wright (1942). The succession can be correlated in detail with that of north Lincolnshire (Wood *in* Smart & Wood 1976).

Magnificently exposed in the Flamborough Head cliffs, the coastal Upper Chalk is harder than that of southern England. The Senonian fauna typifies the northern sub-province, and exhibits greater affinity with the German–Russian successions than with the Chalk of the Anglo–Paris Basin (see p. 53). The present subdivision is based on work on the coastal exposures by Rowe (1904) and Wright & Wright (1942) who also zoned all the inland sections. Wright & Wright formalized Rowe's *Hagenowia rostrata* and *Inoceramus lingua* Zones as local equivalents of the *coranguinum* and *pilula* Zones of the southern sub-province. More recently, Ernst (1966) has provided tentative correlations with the Coniacian and Santonian of Lägerdorf in Germany. Exact correlation of the post-*Marsupites* chalk is difficult: N. B. Peake (personal communication) considers that the Sewerby section all falls within the *pilula* Zone, so that only some of the inland pits, recognized by Rowe (1904) and Wright & Wright (1942) as younger than the Sewerby section, might fall into the *quadrata* Zone.

Supplementary note on the Lincolnshire Chalk: For the Cenomanian see Jukes-Browne & Hill (1903) and Bower & Farmery (1910). Jeans (1968, Fig. 4) gave an outline succession based on sections in south Lincolnshire. The stratigraphy and age of the thin representative of the Plenus Marls and the Black Band were covered by Jefferies (1963) and Wood (*in* Smart & Wood 1976). Details of the post-Cenomanian succession have been given by Hill (1902), Burnett (1904), Jukes-Browne & Hill (1903, 1904); Rowe's posthumously published fieldnotes (1929) included a number of measured sections and extensive faunal lists. Although approximate zonal boundaries are suggested in the literature, the positions of many of these relative to the standard southern English successions are open to question (discussion by Wood *in* Smart & Wood 1976). The highest chalk seen at outcrop, however, yields *Inoceramus schloenbachi*, and can be confidently assigned to the *cortestudinarium* Zone.

The North Sea (Column 23)

The Chalk has received rather more attention than the Lower Cretaceous and Hancock & Scholle (1975) have summarized much of the available data. The Chalk persists, except where modified by intra- and post-late Cretaceous faulting or by halokinesis, as a virtually continuous sheet throughout the southern North Sea and over much of the northern sector as well.

The gradual passage at some horizons to more marly and eventually shaly sequences in the more northerly regions is now well-known, as also are the intercalations of red chalks at intervals in the late Campanian and Maastrichtian. The southern North Sea columns published by Rhys (1974) and the more northerly ones shown here demonstrate the development of all the Upper Cretaceous stages and the considerable increases in thickness (up to 1,000 m or more in the Central Graben area and the Anglo–Dutch Basin) which have been proved in many areas. The corollary of reduced thickness by inversion is limited to certain areas such as the Sole Pit area. The considerable increase in thickness as compared with onshore Britain is due in part to the virtually universal presence of Maastrichtian, which appears to have been transgressive over wide areas. Beds of Maastrichtian and Danian Chalk are known within the Lower Paleocene succession, associated with the Central Graben, and are interpreted as slumped. By the close of the Cretaceous a median deeper water facies had developed in the centre of an essentially simple basin which persisted through the ensuing Tertiary.

Correlation and dating of the vast majority of these sequences has been based primarily on smaller foraminifera. Despite the rare occurrence of orbitoids in southern Sweden and the Netherlands, no examples of larger foraminifera are reported from the North Sea.

However *Globotruncana* (and to a lesser degree *Bolivinoides*), stratigraphically among the most useful of all the smaller foraminifera, are fairly common to the most northerly latitudes yet evaluated and have provided, together with many of the benthonic foraminifera (utilized particularly in the Netherlands and Germany for correlation), a reasonable basis for the stage determinations indicated in the columns.

Antrim and Derry (Columns 24 and 25)

The succession given here is based on Hancock (1961), McGugan (1957, 1974), Reid (1971) and Wood (1967), who reviewed the previous literature.

The boundary between the *mantelli* and *rhotomagense* Zones occurs somewhere well up in the Glauconite Sands, the higher levels of which contain *Acanthoceras* sp., *Actinocamax primus, Oxytoma seminudum, Aequipecten arlesiensis* and *Chlamys fissicosta*; these fossils correlate with the Totternhoe Stone of the Chilterns. The overlying Lower Glauconitic Sandstone (Reid 1971) (= Basement Sands of Hancock

1961 = Zone of *Exogyra columba* of Hume 1897) is definitely Cenomanian, but assignment to the *naviculare* Zone is little more than guesswork.

The dating of the Upper Glauconitic Sandstone and the succeeding White Limestone has been reviewed in Hancock (1961), Manning *et al.* (1970), Reid (1971, 1973), Wood (1967, and *in* Wilson 1972). The discovery of *Inoceramus involutus* in the Inoceramus Band (Wood 1974) establishes a correlation with the lower part of the *coranguinum* Zone. The underlying beds with *Cretirhynchia robusta* and *Conulus raulini* are thus in all probability of *cortestudinarium* Zone age, while the overlying greensands with *Gibbithyris hibernica*, *Conulus albogalerus* and *Echinocorys* sp. belong to the Santonian part of the *coranguinum* Zone.

The biostratigraphy of the White Limestone is described in fuller detail by Wood & Fletcher (in press), whilst Fletcher (in press) has been able to recognize 12 members within this formation.

West Scotland (Column 26)

Widely scattered outcrops of Cretaceous rocks occur in Skye, Raasay, Scalpay, Eigg, Morvern, Mull and Arran. As in Ireland, there is a lower clastic division, and an upper one of limestone. In addition there is usually another clastic division, of uncertain age, above the limestone and below the basalts.

Most of the occurrences are described in memoirs of the Geological Survey, and all this earlier work is summarized by Lee & Pringle (1932). The sequence given here is based on these and recent work. The column given is restricted to Argyll, where the section is most complete.

Arran: Chalk, partly silicified, of unknown age, occurs caught up in the volcanic agglomerate of the Central Ring Complex.

Argyll: The Morvern Greensand is a formational name introduced here for the Cretaceous beds below the Loch Aline Glass Sand in Mull and Morvern. The type locality is the waterfall section 2.66 km north of Ardtornish Point, east shore of Loch Aline, Morvern, Argyllshire. In the cliff section east of Auchnacraig Farm, east Mull, the basal member of the Morvern Greensand has yielded *Hyphoplites* gr. *curvatus arausionensis* which suggests the lower part of the *mantelli* Zone.

A small *Cardiaster* sp. and an asteroid are almost the only fossils known from the Loch Aline Glass Sand. Our correlation of the two Cenomanian clastic formations of Argyllshire with the Glauconite Sands and Yellow Sandstone of Antrim is guesswork. In terms of lithologies the closest approach between the two regions is between the Loch Aline Glass Sand and the Lower Glauconitic Sandstone south-west of Belfast, and this could be a possible correlation.

Collections from Beinn Iadain made by C. V. Jeans have shown that there are remanié phosphatic Senonian faunas beneath the chalk. Reid (personal communication) has suggested that the sponges, which include *Rhizopoterion cribrosum* and cf. *Callopegma obconicum*, correlate with the Antrim Sponge Beds (*socialis* Zone). The brachiopods (and echinoids?) probably belong to the *coranguinum* Zone (equivalent to horizons both above and below the Inoceramus Band of Antrim) although some of the brachiopods have a Cenomanian aspect.

The limestone division was recognized to be chalk by Judd (1878), but in Mull and Morvern is now wholly silicified. Only two macrofossils have been recorded: *Belemnitella mucronata* by Judd (1878), which is probably lost, and *Salenia geometrica* by Manson (Pringle & Manson 1934). Both suggest the *mucronata* Zone, which agrees with the maximum transgression of the Chalk in Ireland. On the other hand the Chalk at Allt-na-Teangaidh in Mull contains a microfauna which includes *Gavelinella thalmanni* and *Stensioeina gracilis*, and these are early Santonian.

Above the Chalk and below the basalts there are up to 2·5 m of breccia or conglomerate of chalk pebbles in a sandy matrix (Bailey 1924). No fossils are known and this conglomerate may be Cretaceous or early Tertiary. Srivastava (1975) has recorded *Aquilopollenites* from the inter-basaltic lignites in Mull, and he considers this genus to be Maastrichtian. However, there is no radiometric evidence, as yet, that any of the basalts are pre-Tertiary.

Eigg, Skye, Raasay and Scalpay: The outcrops in this region are even smaller and more scattered than those further south, and there is great variation from place to place, but a three-fold division into a lower and upper sandy series with chalk in the middle is often present. Some of the Cretaceous in Eigg has been described under the name of the Laig Gorge Beds (Hudson 1960). The chalk is unsilicified but sometimes metamorphosed.

The only locality where fossils have been found in the lower sandy series is in southern Scalpay (Wood *in* Peach *et al.* 1910); they are vaguely suggestive of a Cenomanian age. The foraminifera in the Chalk have been described and discussed by Adams (1960) who concluded that they indicated a Senonian age. No fossils are known from the upper sandy series.

ACKNOWLEDGEMENTS. We are indebted particularly to Dr. R. Casey, F.R.S., who convened the working group from its inception until 1974, and has continued to help us until the paper was completed: it owes much to his scholarship and experience. We thank another member of our group, Mr. N. F. Hughes, who advised us throughout, and are also grateful to the following who have advised in sections relevant to their fields of specialization: Professor P. Allen, F.R.S., Dr. E. G. Kauffman, Dr. M. B. Hart, Professor J. F. Kirkaldy, Dr. H. G. Owen, Mr. N. B. Peake and Mr. C. W. Wright. Many other friends too numerous to mention answered our individual queries whenever called upon.

8. References

ADAMS, C. G. 1960. A note on the age of the Laig Gorge Beds, Eigg. *Geol. Mag.* **97,** 322–25.

ALCAYDÉ, G. 1968. Carte géologique, 1/50 000 Amboise. *Bur. Rech. géol. minièr.*

—— 1970. Carte géologique, 1/50 000 Saumur. *Bur. Rech. géol. minièr.*

—— 1971. Carte géologique, 1/50 000 Langeais. *Bur. Rech. géol. minièr.*

ALI, M. T. 1975. Environmental implications of infillings in the Upper Greensand of the Beer district, south Devon. *Proc. Geol. Ass.* **85,** 519–31.

ALLEN, P. 1955. The age of the Wealden in north-western Europe. *Geol. Mag.* **92,** 265–81.

—— 1959. The Wealden environment: Anglo-Paris Basin. *Phil. Trans. R. Soc.* B**242,** 283–346.

—— 1965. L'age du Purbecko-Wealdien d'Angleterre. *Mém. Bur. Rech. géol. minièr.* **34,** 321–26.

—— 1967. Origin of the Hastings facies in north-western Europe. *Proc. Geol. Ass.* **78,** 27–105.

—— 1976. Wealden of the Weald: a new model. *Proc. Geol. Ass.* **86,** 389–437.

Anderson, F. W. 1967. Ostracods from the Weald Clay of England. *Bull. geol. Surv. Gt Br.* **27,** 237–69.

—— 1971. Appendix B. The sequence of ostracod faunas in the Wealden and Purbeck of the Warlingham Borehole. *Bull. geol. Surv. Gt Br.* **36,** 122–38.

—— 1973. The Jurassic-Cretaceous transition: the non-marine ostracod faunas. Pp. 101–110 *in* Casey, R. & Rawson, P. F. (Eds), *q. v.*

—— & Bazley, R. A. B. 1971. The Purbeck Beds of the Weald (England). *Bull. geol. Surv. Gt Br.* **34,** 1–173.

——, —— & Shephard-Thorn, E. R. 1967. The sedimentary and faunal sequence of the Wadhurst Clay (Wealden) in boreholes at Wadhurst Park, Sussex. *Bull. geol. Surv. Gt Br.*, **27,** 171–235.

Andreieff, P., Bouysse, P., Curry, D., Fletcher, B. N., Hamilton, D., Monciardini, C. & Smith, A. J. 1975. The stratigraphy of post-Palaeozoic sequences in part of the Western Channel. *Phil. Trans. R. Soc.* A**279,** 79–97.

Arkell, W. J. 1947. The geology of the country around Weymouth, Swanage, Corfe and Lulworth. *Mem. geol. Surv. Gt Br.*, 386 + xii pp.

——, Furnish, W. M., Kummel, B., Miller, A. K., Moore, R. C., Schindewolf, O. H., Sylvester-Bradley, P. C. & Wright, C. W. 1957. *Treatise on Invertebrate Paleontology. L. Mollusca* 4. Geol. Soc. Am. & Univ. Kansas Press, 490 + xxii pp.

Arnaud, H. 1877. Mémoire sur le Terrain Crétacé du Sud-ouest de la France. *Mém. Soc. géol. Fr.* 2nd ser. **10**(4), 1–110.

Bailey, E. B. 1924. The desert shores of the Chalk seas. *Geol. Mag.* **61,** 102–16.

Bailey, H. W. 1975. A preliminary microfaunal investigation of the lower Senonian at Beer, south-east Devon. *Proc. Ussher Soc.* **3,** 280–85.

Ballance, P. F. 1964. The beds between the Kimeridge and Gault Clays in the Thame-Aylesbury neighbourhood. *Proc. Geol. Ass.* **74,** 393–418.

Barbier, R. & Thieuloy, J. P. 1965. Étage valanginien. Pp. 79–96 *in* Colloque Sur le Crétacé Inférieur. *Mém. Bur. Rech. géol. minièr* **34.**

Barr, F. T. 1962. Upper Cretaceous planktonic foraminifera from the Isle of Wight, England. *Palaeontology* **4,** 552–580.

—— 1966. The foraminiferal genus *Bolivinoides* from the Upper Cretaceous of the British Isles. *Palaeontology* **9,** 220–243.

—— & Cordey, W. G. 1964. Some Upper Cretaceous foraminifera from the Chapman Collection (1892). *J. Paleont.* **38,** 306–10.

Barrois, C. 1874. Sur le Gault et sur les couches entre lesquelles il est compris dans le bassin de Paris. *Ann. Soc. géol. Nord* **2,** 1–61.

—— 1876. *Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande.* Lille, 232 pp.

Bartenstein, H. 1956. Zur Mikrofauna des englischen Hauterive. *Senck. leth.* **37,** 509–533.

Barthe, A., Boillot, G. & Deloffre, R. 1967. Anticlinaux affectant le Crétacé à l'entrée de la Manche occidentale. *C. R. Acad. Sci.* **264,** 2725–8.

Batten, D. J. 1975. Wealden palaeoecology from the distribution of plant fossils. *Proc. Geol. Ass.* **85,** 433–58.

Bellier, J. P. 1971. Les Foraminifères planctoniques du Turonien-type. *Revue Micropaléont.* **14,** 85–90.

Berggren, W. A. 1962. Some planktonic Foraminifera from the Maestrichtian and type Danian stages of southern Scandinavia. *Stockh. Contr. Geol.* **9,** 1–106.

—— 1964. The Maestrichtian, Danian and Montian stages and the Cretaceous-Tertiary boundary. *Stockh. Contr. Geol.* **11,** 103–176.

Berthou, P.-Y. & Lauverjat, J. 1974. La limite Cénomanien—Turonien dans la série à Vascoceratidés de l'embouchure du rio Mondego (Beira littoral, Portugal). *C. r. hebd. Séanc. Acad. Sci., Paris* **278D,** 1463–66.

Bignot, G. & Larsonneur, Cl. 1969.

Etude du Crétacé supérieur au large du Cotentin et remarques sur les *Planorbulina* du Crétacé supérieur et du Paléocène. *Revue Micropaléont.* **12,** 25–39.

Billinghurst, S. A. 1927. On some new Ammonoidea from the Chalk Rock. *Geol. Mag.* **64,** 511–18.

Birkelund, T. 1966. Die Entwicklung der jüngsten Scaphiten und ihre stratigraphische Bedeutung im baltischen Gebiet. *Ber. deutsch. Ges. geol. Wiss., A, Geol. Paläont.* **11,** 737–44.

Boillot, G. & Musellec, P. 1975. Origine de la Manche d'après une carte géologique au 1 : 1 000 000. *Phil. Trans. R. Soc.* **A279,** 21–27.

Boswell, P. G. H. 1927. The Geology of the Country around Ipswich. *Mem. geol. Surv. Gt Br.,* 121 pp.

Bower, C. R. & Farmery, J. R. 1910. The zones of the Lower Chalk of Lincolnshire. *Proc. Geol. Ass.* **21,** 333–59.

Breistroffer, M. 1947. Sur les Zones d'Ammonites dans l'Albien de France et d'Angleterre. *Trav. Lab. géol. Univ. Grenoble* **26,** 17–104.

Brinkmann, R. 1937. Biostratigraphie des Leymeriellenstammes nebst Bemerkungen zur Paläogeographie des Nordwestdeutschen Alb. *Mitt. geol. St Inst. Hamb.* **16,** 1–18.

Bristow, C. R. & Bazley, R. A. 1972. Geology of the country around Royal Tunbridge Wells. *Mem. Geol. Surv. Gt Br.,* 161 pp.

Bromley, R. G. 1965. *Studies in the lithology and conditions of sedimentation of the Chalk Rock and comparable horizons.* Unpublished Ph D. Thesis, University of London, 355 pp.

—— 1967. Some observations on burrows of thalassinidean Crustacea in chalk hardgrounds. *Q. Jl geol. Soc. Lond.* **123,** 157–82.

——, Schulz, M.-G. & Peake, N. B. 1975. Paramoudras: giant flints, long burrows and the early diagenesis of chalks. *Biol. Skr.* **20** (10), 1–31.

Brongniart, A. 1829. *Tableau des Terrains qui composent l'écorce du globe ou essai sur la structure de la partie connue de la Terre.* Paris, 435 pp.

Bruckshaw, J. M., Goguel, J., Harding, H. J. B. & Malcor, R. 1961. The work of the Channel Tunnel Study Group 1958–1960. *Proc. Inst. Civ. Eng.* **18,** 149–78.

Brydone, R. M. 1912. *The stratigraphy of the Chalk of Hants.* London, Dulau & Co. Ltd., 116 pp.

—— 1914. The Zone of *Offaster pilula* in the South English Chalk. Parts I–IV. *Geol. Mag.* (6) **1,** 359–69, 405–11, 449–57, 509–13.

—— 1915. The *Marsupites* Chalk of Brighton. *Geol. Mag.* (6) **2,** 12–15.

—— 1917. The base of the Chalk Zone of *Holaster planus* in the Isle of Wight. *Geol. Mag.* (6) **4,** 245–9.

—— 1918. The thickness of the Zone of *Belemnitella mucronata* in the Isle of Wight. *Geol. Mag.* (6) **5,** 350–54.

—— 1932a. The Lower Beds of the Chalk near Ipswich. *Jl Ipswich Dist. Nat. Hist. Soc.* **1,** 153–57.

—— 1932b. *Uintacrinus* in North Suffolk. *Jl Ipswich Dist. Nat. Hist. Soc.* **1,** 158–61.

Burnaby, T. P. 1962. The palaeoecology of the Foraminifera of the Chalk Marl. *Palaeontology* **4,** 599–608.

Burnett, A. 1904. The Upper Chalk of North Lincolnshire. *Geol. Mag.* (5) **1,** 172–6.

Busnardo, R. 1965. Le stratotype du Barrémien. 1 Lithologie et Macrofaune. Pp. 101–16 *in* Colloque sue le Crétacé inférieur. *Mém. Bur. Rech. géol. minièr* **34.**

Butt, A. A. 1966. Foraminifera of the type Turonian. *Micropaleontology* **12,** 168–82.

Caldwell, W. G. E. (Editor) 1975. The Cretaceous System in the Western Interior of North America. *Geol. Soc. Can., Spec. Pap.* **13,** 666 pp.

Carter, D. J. & Destombes, J. P. 1972. Stratigraphie du Cénomanien du détroit du Pas-de-Calais. Pp. 117–21 *in* Colloque sur la géologie de la Manche. *Mém. Bur. Rech. géol. minièr.* **79.**

—— & Hart, M. B. *in press.* Aspects of mid-Cretaceous stratigraphical micropalaeontology. *Bull. Br. Mus. nat. Hist.* (Geology).

Casey, R. 1961a. The stratigraphical palaeontology of the Lower Greensand. *Palaeontology* **3,** 487–621.

—— 1961b. Geological age of the Sandringham Sands. *Nature* **190,** 1100.

—— 1962. The ammonites of the Spilsby Sandstone, and the Jurassic-Cretaceous boundary. *Proc. geol. Soc. Lond.* **1598,** 95–100.

—— 1963. The dawn of the Cretaceous period in Britain. *Bull. S.-East Un. Sci. Socs* **117,** 1–15.

—— 1964. *In* DODSON, M. H., REX, D. C., CASEY, R. & ALLEN, P. Glauconite dates from the Upper Jurassic and Lower Cretaceous. *In* The Phanerozoic Time-scale. *Q. Jl geol. Soc. Lond.* **120S,** 145–58.

—— 1967. Pp. 90–91 in *Ann. Rep. Inst. geol. Sci.* for 1966. H.M.S.O., London.

—— 1973. The ammonite succession at the Jurassic-Cretaceous boundary in eastern England. Pp. 193–266 *in* CASEY, R. & RAWSON, P. F. (Eds), *q. v.*

——, ALLEN, P., DÖRHÖFER, G., GRAMANN, F., HUGHES, N. F., KEMPER, E., RAWSON, P. F. & SURLYK, F. 1975. Stratigraphical subdivision of the Jurassic-Cretaceous boundary beds in NW Germany. *Newsl. Stratigr.* **4** (1), 4–5.

—— & BRISTOW, C. R. 1964. Notes on some ferruginous strata in Buckinghamshire and Wiltshire. *Geol. Mag.* **101,** 116–28.

—— & GALLOIS, R. W. 1973. The Sandringham Sands of Norfolk. *Proc. Yorks. geol. Soc.* **40,** 1–22.

——, MESEZHNIKOV, M. S. & SHULGINA, N. I., *in press.* Correlation of the Jurassic/Cretaceous boundary deposits of England, the Russian platform, pre-Polar Urals and Siberia. *Dokl. Akad. Nauk. SSSR.* **227** (in Russian).

—— & RAWSON, P. F. (Editors) 1973a. *The Boreal Lower Cretaceous.* Geol. Jl Spec. Iss. 5, Seel House Press, Liverpool. 448 pp.

—— & —— 1973b. A review of the boreal Lower Cretaceous. Pp. 415–30 *in* CASEY, R. & RAWSON, P. F. (Eds), *q. v.*

CHATWIN, C. P. & WITHERS, T. H. 1908. The zones of the Chalk in the Thames Valley between Goring and Shiplake. *Proc. Geol. Ass.* **20,** 390–419.

CHESHER, J. A., DEEGAN, C. E., ARDUS, D. A., BINNS, P. E. & FANNIN, N. G. T. 1972. IGS marine drilling with m. v. *Whitehorn* in Scottish waters 1970–71. *Rep. Inst. geol. Sci.* **72/10,** 25 pp.

COBBAN, W. A. & SCOTT, G. R. 1972. Stratigraphy and Ammonite Fauna of the Graneros Shale and Greenhorn Limestone near Pueblo, Colorado. *Prof. Pap. U.S. geol. Surv.* **645,** 1–108.

COOKSON, I. C. & HUGHES, N. F. 1964. Microplankton from the Cambridge Greensand (mid Cretaceous). *Palaeontology* **7,** 37–59.

COOPER, M. R. 1972. The Cretaceous stratigraphy of San Nicolau and Salinas, Angola. *Ann. S. Afr. Mus.* **60,** 245–51.

—— 1973. Cenomanian ammonites from Novo Redondo, Angola. *Ann. S. Afr. Mus.* **62,** 41–67.

—— 1974. The Cretaceous stratigraphy of south-central Africa. *Ann. S. Afr. Mus.* **66,** 81–107.

COQUAND, H. 1856. Notice sur la formation crétacée du département de la Charente. *Bull. Soc. géol. Fr.* (2) **14,** 55–98.

—— 1857. Position des *Ostrea columba* et *biauriculata* dans le groupe de la craie inférieure. *Bull. Soc. géol. Fr* (2) **14,** 745–66.

—— 1858. *Description physique, géologique, paléontologique et minéralogique du département de la Charente.* **1,** 542 pp. Besançon, Conseil Général.

—— 1861. Sur la convenance d'établir dans le groupe inférieur de la formation cretacée un nouvel étage. *Mém. Soc. Emul. Provence* **1,** 127–35.

CURRY, D. 1962. A Lower Tertiary outlier in the central English Channel, with notes on the beds surrounding it. *Q. Jl geol. Soc. Lond.* **118,** 177–205.

—— 1964. On rotten flint pebbles in the Palaeogene of Southern England. *Proc. Geol. Ass.* **74,** 457–60.

——, HAMILTON, D. & SMITH, A. J. 1970. Geological and shallow subsurface geophysical investigations in the Western Approaches to the English Channel. *Rep. Inst. geol. Sci.* **70/3,** 12 pp.

——, HERSEY, J. B., MARTINI, E. & WHITTARD, W. F. 1965. The geology of the Western Approaches of the English Channel. II: Geological interpretation aided by boomer and sparker records. *Phil. Trans. R. Soc.* **B248,** 315–51.

——, Murray, J. W. & Whittard, W. F. 1965. The geology of the Western Approaches of the English Channel. III: The *Globigerina* silts and associated rocks. *Colston Pap.* **17,** 239–64.

—— & Smith, A. J. 1975. New discoveries concerning the geology of the central and eastern parts of the English Channel. *Phil. Trans. R. Soc.* **A279,** 155–67.

Debelmas, J. & Thieuloy, J. P. 1965. Étage Hauterivien. Pp. 85–96 *in* Colloque sur le Crétacé inférieur. *Mem. Bur. Rech. Géol. minièr* **34.**

Delaunay, P. 1934. *Le Sol Sarthois,* 4: *Les zones cretacées.* Le Mans. Monnoyer, 541–762.

Deroo, G. 1966. Cytheracea (Ostracodes) du Maastrichtien de Maastricht (Pays-Bas) et des régions voisines; résultats stratigraphiques et paléontologiques de leur étude. *Meded. geol. Sticht.,* **C.2**(2), 197 pp.

Desor, E. 1854. Quelques mots sur l'étage inférieur du groupe neocomien (étage Valanginien). *Bull. Soc. Sci. nat. Neuchâtel* **3,** 172–80.

Destombes, P. 1973. Hoplitidae et zonation nouvelle de l'Albien inférieur de Bully-St Martin (Bray Occidental). *C. r. hebd. Séanc. Acad. Sci. Paris* **277D,** 2145–48.

—— & Shephard-Thorn, E. R. 1971. Geological results of the Channel Tunnel site investigations 1964–65. *Rept. Inst. Geol. Sci.* **71/11,** 12 pp.

Dilley, F. C. 1969. The foraminiferal fauna of the Melton Carstone. *Proc. Yorks. geol. Soc.* **37,** 321–22.

Dines, H. G., Buchan, S., Holmes, S. C. A. & Bristow, C. R. 1969. Geology of the Country around Sevenoaks and Tonbridge. *Mem. Geol. Surv. Gt Br.,* 183 pp.

Dingwall, R. G. 1971. The structural and stratigraphical geology of a portion of the eastern English Channel. *Rep. Inst. Geol. Sci.* **71/8,** 24 pp.

Donze, P. & Thieuloy, J. P. 1975. Sur l'extrême condensation du Valanginien supérieur dans le Jura neuchâtelois, en particulier dans le stratotype de Valangin, et sa signification dans l'ensemble des formations valanginiennes du Sud-Est de la France. *C. r. hebd. Séanc. Acad. Sci., Paris* **280D,** 1661–64.

Downes, W. 1882. The Zones of the Blackdown Beds, and their correlation with those at Haldon, with a list of the Fossils. *Q. Jl geol. Soc. Lond.* **38,** 75–94.

Drummond, P. V. O. 1970. The Mid-Dorset Swell. Evidence of Albian-Cenomanian movements in Wessex. *Proc. Geol. Ass.* **81,** 679–714.

Dumont, A. 1850. Rapport sur la carte géologique du royaume. *Bull. Acad. r. Belg. Cl. Sci.* **16,** 351–73.

Eames, F. E. 1968. The Tertiary Cretaceous boundary. *Mem. geol. Soc. India,* **2,** 361–68.

Edmonds, E. A. & Dinham, C. H. 1965. Geology of the Country around Huntingdon and Biggleswade. *Mem. Geol. Surv. Gt Br.,* 90 pp.

——, McKeown, M. C. & Williams, M. 1969. South West England. *British Regional Geology,* H.M.S.O. (3rd edit.).

Ennis, W. C. 1937. The Upper Beds of the Speeton Clay. *Trans. Hull geol. Soc.* **7** (5), 130–38.

Ernst, G. 1966. Fauna, Ökologie und Stratigraphie der mittelsantonen Schreibkreide von Lägerdorf (SW-Holstein). *Mitt. geol. St Inst. Hamb.* **35,** 115–50.

Falcon, N. L. & Kent, P. E. 1960. Geological results of petroleum exploration in Britain 1945–1957. *Mem. geol. Soc. Lond.* **2,** 56 pp.

Fisher, O. 1896. Vertical Tertiaries at Bincombe, Dorset. *Geol. Mag.* (4) **3,** 246–7.

Fitton, W. H. 1847. A stratigraphical account of the section from Atherfield to Rocken End, on the south-west coast of the Isle of Wight. *Q. Jl geol. Soc. Lond.* **3,** 289–327.

Fletcher, B. N. 1966. *Lower Cretaceous foraminifera from the Speeton Clay of Yorkshire.* Unpublished Ph.D. Thesis, University of Hull, 428 pp.

—— 1969. A lithological subdivision of the Speeton Clay C Beds (Hauterivian), East Yorkshire. *Proc. Yorks. geol. Soc.* **37,** 323–27.

—— 1973. The distribution of Lower Cretaceous (Berriasian-Barremian) foraminifera in the Speeton Clay of Yorkshire, England. Pp. 161–68 *in* Casey, R. & Rawson, P. F. (Eds), *q. v.*

Fletcher, T. P. *in press.* The lithostratigraphy of the Chalk (Ulster White Limestone Formation) in Northern Ireland. *Bull. geol. Surv. Gt Br.*

Forbes, C. L. 1960. Field Meeting in the Cambridge district. *Proc. Geol. Ass.* **71,** 233–41.

Forbes, E. 1851. On the succession of Strata and distribution of organic remains on the Dorsetshire Purbecks. *Rept. Br. Ass. Adv. Sci.* notes and abstracts, 79–81.

Gallois, R. W. 1975a. The base of the Carstone at Hunstanton. Part II. *Bull. geol. Soc. Norfolk* **27,** 21–27.

—— 1975b. A borehole section across the Barremian–Aptian boundary (Lower Cretaceous) at Skegness, Lincolnshire. *Proc. Yorks. geol. Soc.* **40,** 499–503.

Gaster, C. T. A. 1924. The Chalk of the Worthing District of Sussex. *Proc. Geol. Ass.* **35,** 89–110.

—— 1925. Excursion to the Worthing district, Sussex. *Proc. Geol. Ass.* **36,** 99–102.

—— 1930. Chalk Zones in the neighbourhood of Shoreham, Brighton and Newhaven, Sussex. *Proc. Geol. Ass.* **40,** 328–40.

—— 1937. The stratigraphy of the Chalk of Sussex. Pt. I. West Central Area—Arun Gap to Valley of the Adur, with zonal map. *Proc. Geol. Ass.* **48,** 356–73.

—— 1939. The stratigraphy of the Chalk of Sussex. Pt. II. Eastern Area—Seaford to Cuckmere Valley and Eastbourne, with zonal map. *Proc. Geol. Ass.* **50,** 510–26.

—— 1941. The Chalk Zones of *Offaster pilula* and *Actinocamax quadratus. Proc. Geol. Ass.* **52,** 210–15.

—— 1944. The stratigraphy of the Chalk of Sussex. Pt. III. Western Area—Arun Gap to the Hampshire boundary, with zonal map. *Proc. Geol. Ass.* **55,** 173–88.

—— 1951. The stratigraphy of the Chalk of Sussex. Pt. IV. East Central Area—between the Valley of the Adur and Seaford, with zonal map. *Proc. Geol. Ass.* **62,** 31–64.

Goharian, F. 1971. Étude Micropaléontologique du Campanien-type des Charentes. Conséquences stratigraphiques. *Revue Micropaléont.* **14,** 20–34.

Gorsel, J. T. van 1973. The type Campanian and the Campanian–Maastrichtian boundary in Europe. *Geologie Mijnb.* **52,** 141–46.

Griffith, C. & Brydone, R. M. 1911. *The zones of the Chalk in Hants.* London, Dulau and Co. Ltd., 35 pp.

Grossouvre, A. de 1895–1901. Recherches sur la craie supérieure 1: stratigraphie générale. *Mém. Serv. Carte géol. dét. Fr.* 1013 pp.

Groupe Norois 1972. Contribution à l'étude stratigraphique des terrains affleurant en Manche centrale et orientale. Pp. 123–70 *in* Colloque sur la géologie de la Manche. *Mém. Bur. Rech. géol. minièr* **79.**

Guillier, A. 1886. *Géologie du département de la Sarthe.* Le Mans (Monnoyer) and Paris, 430 pp.

Haefeli, C., Maync, W., Oertli, H. J. & Rutsch, R. F. 1965. Die Typus Profil des Valanginien und Hauterivien. *Bull. Verein. schweiz. Petrol. Geol. u.-Ing.* **31,** 41–75.

d'Halloy, O. 1822. Observations sur un essai de carte géologique de la France, des Pays-Bas, et des contrées voisines. *Annl mines* **7,** 353–76.

Hamblin, R. J. O. & Wood, C. J. 1976. The Cretaceous (Albian–Cenomanian) stratigraphy of the Haldon Hills, south Devon, England. *Newsl. Stratigr.* **4** (3), 135–49.

Hancock, J. M. 1959. Les ammonites du Cénomanien de la Sarthe. Pp. 249–52 *in* Colloque sur le Crétacé Supérieur français. *C. r. Congr. Socs sav.*, Dijon.

—— 1961. The Cretaceous system in Northern Ireland. *Q. Jl geol. Soc. Lond.* **117,** 11–36.

—— 1967. Some Cretaceous–Tertiary marine faunal changes. Pp. 91–104 in *The Fossil Record.* Geol. Soc. Lond.

—— 1969. Transgression of the Cretaceous sea in south-west England. *Proc. Ussher Soc.* **2,** 61–83.

—— 1972. (Editor). Crétacé de l'Angleterre, Pays de Galles, Écosse. *Lexique Strat. Int.* 1 (3a XI), 162 pp.

——, Kennedy, W. J. & Klaumann, H. 1972. Ammonites from the transgressive Cretaceous on the Rhenish Massif, Germany. *Palaeontology* **15,** 445–9.

—— & Scholle, P. A. 1975. Chalk of the North Sea. Pp. 413–27 *in* Woodland, A. W. (Ed.), *q. v.*

Hart, M. B. 1971. Micropalaeontological evidence of mid-Cenomanian flexuring in south west England. *Proc. Ussher Soc.* **2,** 315–25.

—— 1973a. Foraminiferal evidence for the age of the Cambridge Greensand. *Proc. Geol. Ass.* **84,** 65–82.

—— 1973b. Some observations on the Chert Beds (Upper Greensand) of south west England. *Proc. Ussher Soc.* **2,** 599–608.

—— 1973c. A correlation of the macrofaunal and microfaunal zonations of the Gault Clay in south-east England. Pp. 267–88 *in* Casey, R. & Rawson, P. F. (Eds), *q. v.*

—— 1975. Microfaunal analysis of the Membury Chalk succession. *Proc. Ussher Soc.* **3,** 280–5.

Hébert, E. 1863. Note sur la craie blanche et la craie marneuse dans le bassin de Paris, et sur la division de ce dernier étage en quatre assises. *Bull. Soc. géol. Fr.* (2) **20,** 605–31.

Hewitt, H. D. 1924. Notes on some Chalk sections in the district around Thetford, Norfolk. *Proc. Geol. Ass.* **35,** 220–44.

—— 1935. Further notes on the Chalk of the Thetford district, Norfolk. *Proc. Geol. Ass.* **46,** 18–37.

Hill, W. 1888. On the Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire. *Q. Jl geol. Soc. Lond.* **44,** 320–67.

—— 1902. Note on the Upper Chalk of Lincolnshire. *Geol. Mag.* (4) **9,** 404–406.

Hiltermann, H. 1963. Zur Entwicklung der Benthos-Foraminifera *Bolivinoides.* Pp. 198–208 *in* van Koenigswald *et al.* (Eds), *Evolutionary trends in formaminifera.* Elsevier, 355 pp.

Hinte, J. E. van 1965. The type Campanian and its planktonic Foraminifera. *Proc. K. ned. Akad. Wet.* B **68,** 8–28.

—— 1976. A Cretaceous Time Scale. *Bull. Am. Ass. Petrol. Geol.* **60,** 498–516.

Hofker, J. 1962. Correlation of the Tuff Chalk of Maestricht (type Maestrichtian) with the Danske Kalk of Denmark (type Danian), the stratigraphic position of the type Montian, and the planktonic foraminiferal faunal break. *J. Paleont.* **36,** 1051–89.

Howitt, F. 1964. Stratigraphy and structure of the Purbeck inliers of Sussex (England). *Q. Jl geol. Soc. Lond.* **120,** 77–113.

—— 1974. North Sea oil in a world context. *Nature* **249,** 700–703.

Hudson, J. D. 1960. The Laig Gorge Beds, Isle of Eigg. *Geol. Mag.* **97,** 313–22.

Hughes, N. F. 1958. Palaeontological evidence for the age of the English Wealden. *Geol. Mag.* **95,** 41–49.

—— 1973. Palynological time-correlation of English Wealden with boreal marine successions. Pp. 185–92 *in* Casey, R. & Rawson, P. F. (Eds), *q. v.*

—— & Croxton, C. A. 1973. Palynologic correlation of the Dorset 'Wealden'. *Palaeontology* **16,** 567–601.

—— & Moody-Stuart, J. C. 1967. Proposed method of recording pre-Quaternary palynological data. *Rev. Palaeobot. Palynol.* **3,** 347–58.

Hume, W. F. 1897. The Cretaceous Strata of Country Antrim. *Q. Jl geol. Soc. Lond.* **53,** 540–606.

Institute of Geological Sciences 1973. *Ann. Rep. Inst. geol. Sci.* for 1973. H.M.S.O., 241 pp.

Jacob, C. 1907. Études paléontologiques et stratigraphiques sur la partie moyenne des terraines crétacés dans les alpes françaises. *Trav. Lab. géol. Univ. Grenoble* **8,** 280–590.

Jeans, C. V. 1968. The origin of the montmorillonite of the European chalk with special reference to the Lower Chalk of England. *Clay Miner.* **7,** 311–329.

—— 1973. The Market Weighton Structure: tectonics, sedimentation and diagenesis during the Cretaceous. *Proc. Yorks. geol. Soc.* **39,** 409–44.

Jefferies, R. P. S. 1962. The palaeoecology of the *Actinocamax plenus* Subzone (Lowest Turonian) in the Anglo-Paris Basin. *Palaeontology* **4,** 609–47.

—— 1963. The stratigraphy of the *Actinocamax plenus* Subzone (Turonian) in the Anglo-Paris Basin. *Proc. Geol. Ass.* **74,** 1–33.

JOHNSON, R. J. 1975. The base of the Cretaceous: a discussion. Pp. 389–402 *in* WOODLAND, A. W. (Ed.), *q. v.*

JUDD, J. W. 1878. The Secondary Rocks of Scotland. Third Paper. The strata of the Western Coast and Islands. With a note on the Foraminifera and other organisms in the Chalk of the Hebrides by T. R. Jones. *Q. Jl geol. Soc. Lond.* **34,** 660–743.

JUIGNET, P. 1968. Faciès littoraux du Cénomanien des environs du Mans (Sarthe). *Bull. Bur. Rech. géol. minièr.* (4) **4,** 5–20.

—— 1973. Chronologie des différentes formations du Cénomanien de la région du Mans (Sarthe). *Reun Ann. Sci. Terre* **1,** 236.

—— & KENNEDY, W. J. 1977. Stratigraphie comparée du Cénomanien du sud d'Angleterre et de Haute Normandie. *Bull. Soc. géol. Normandie amis Mus. Havre* **63,** 1–192.

——, —— & WRIGHT, C. W. 1973. La limite Cénomanien-Turonien dans la région du Mans (Sarthe): stratigraphie et paléontologie. *Annls Paléont.* (Invert.) **59,** 207–42.

JUKES-BROWNE, A. J. 1902. The occurrence of *Marsupites* in Flints on the Haldon Hills. *Geol. Mag.* (4) **9,** 449–50.

—— 1903. On the Zones of the Upper Chalk in Suffolk. *Proc. Geol. Ass.* **18,** 85–94.

—— & HILL, W. 1900–1904. The Cretaceous rocks of Britain. *Mem. geol. Surv. U.K.*, 3 vols.

KAUFFMAN, E. G. 1975. Dispersal and biostratigraphic potential of Cretaceous benthonic bivalvia in the Western Interior. Pp. 163–94 *in* CALDWELL, W. G. E. (Ed.), *q. v.*

—— *in press.* British mid-Cretaceous Inoceramid biostratigraphy. *Annls Mus. Hist. nat., Nice.*

KAYE, P. 1963. The ostracod genus *Neocythere* in the Speeton Clay. *Palaeontology* **6,** 274–81.

—— 1964. Observations on the Speeton Clay (Lower Cretaceous). *Geol. Mag.* **101,** 340–56.

—— 1965. Ostracoda from the Aptian of the Isle of Wight, England. *Paläont. Z.* **39,** 33–50.

—— & BARKER, D. 1965. Ostracoda from the Sutterby Marl (U. Aptian) of south Lincolnshire. *Palaeontology* **8,** 375–90.

—— & —— 1966. Ostracoda from the Upper Tealby Clay (Lower Barremian) of south Lincolnshire. *Palaeontology* **9,** 208–19.

KEEPING, W. 1883. *The fossils and palaeontological affinities of the Neocomian deposits of Upware and Brickhill.* Sedgwick Prize essay for 1879. Cambridge, 167 pp.

KEMPER, E. 1973a. The Valanginian and Hauterivian stages in northwest Germany. Pp. 327–44 *in* CASEY, R. & RAWSON, P. F. (Eds), *q. v.*

—— 1973b. The Aptian and Albian stages in northwest Germany. Pp. 345–60 *in* CASEY, R. & RAWSON, P. F. (Eds), *q. v.*

——, RAWSON, P. F., SCHMID, F. & SPAETH, C. 1974. Die Megafauna der Kreide von Helgoland und ihr biostratigraphische Deutung. *Newsl. Stratigr.* **3,** 121–37.

KENNEDY, W. J. 1969. The correlation of the Lower Chalk of south-east England. *Proc. Geol. Ass.* **80,** 459–560.

—— 1970. A correlation of the uppermost Albian and the Cenomanian of south-west England. *Proc. Geol. Ass.* **81,** 613–77.

—— 1971. Cenomanian ammonites from southern England. *Spec. Pap. Palaeontology* **8,** 133 pp.

—— & COBBAN, W. A. 1976. Aspects of ammonite biology, biogeography and biostratigraphy. *Spec. Pap. Palaeontology* **17,** 94 pp.

—— & GARRISON, R. E. 1975. Morphology and genesis of nodular chalks and hardgrounds in the Upper Cretaceous of southern England. *Sedimentology* **22,** 311–86.

—— & HANCOCK, J. M. 1971. *Mantelliceras saxbii* (Sharpe) and the horizon of the Martimpreyi Zone in the Cenomanian of England. *Palaeontology* **14,** 437–54.

—— & JUIGNET, P. 1973. Observations on the lithostratigraphy and ammonite succession across the Cenomanian–Turonian boundary in the environs of Le Mans (Sarthe, N.W. France). *Newsl. Stratigr.* **2,** 189–202.

KENT, P. E. 1967. Outline geology of the southern North Sea Basin. *Proc. Yorks. geol. Soc.* **36,** 1–22.

—— 1975a. The tectonic development of Great Britain and the surrounding seas. Pp. 3–28 *in* Woodland, A. W. (Ed.), *q. v.*

—— 1975b. Review of North Sea Basin development. *Jl geol. Soc. Lond.* **131,** 435–68.

—— & Dilley, F. C. 1968. The Jurassic-Cretaceous junction at Elsham, North Lincolnshire. *Proc. Yorks. geol. Soc.* **36,** 525–30.

Kilian, W. 1887. Description géologique de la Montagne de Lure (Basses-Alpes). *Ann. Sci. Géol.* **19–20,** 458 pp.

—— 1907–13. Unterkreide (Palaeocretacicum). *In* Frech, F., *Lethaea Geognostica.* II Mesozoic. Vol. iii, Kreide.

Kirkaldy, J. F. 1933. The Sandgate Beds of the Western Weald. *Proc. Geol. Ass.* **34,** 270–311.

Koenen, A. von 1902. Die Ammonitiden des Norddeutschen Neocom. *Abh. preuss. geol. Landesanst.* N. F. **24,** 451 pp., atlas with 55 pls.

Lambert, R. St. J. 1971. The pre-Pleistocene time-scale—a review. Pp. 9–34 *in* Harland, W. B. & Francis, E. H. (Eds) The Phanerozoic time-scale—a supplement, part 1. *Spec. Publs geol. Soc. Lond.* **5.**

Lamplugh, G. W. 1889. On the subdivisions of the Speeton Clay. *Q. Jl geol. Soc. Lond.* **45,** 575–618.

—— 1896. On the Speeton Series in Yorkshire and Lincolnshire. *Q. Jl. geol. Soc. Lond.* **52,** 179–220.

—— 1924. A review of the Speeton Clays. *Proc. Yorks. geol. Soc.* **20,** 1–31.

——, Kitchin, F. L. & Pringle, J. 1923. The concealed Mesozoic Rocks in Kent. *Mem. geol. Surv. Gt Br.,* 248 pp.

Lang, W. D. 1914. The Geology of the Charmouth Cliffs, Beach and Fore-shore. *Proc. Geol. Ass.* **25,** 293–360.

Lapierre, F. 1975. Contribution à l'étude géologique et sédimentologique de la Manche orientale. *Phil. Trans. R. Soc.* **A279,** 177–87.

Lapparent, A. de 1868. Note sur l'étage de la gaize. *Bull. Soc. géol. Fr.* **25,** 868–71.

Larwood, G. P. 1961. The Lower Cretaceous deposits of Norfolk. Pp. 280–92 *in* Larwood, G. P. & Funnell, B. M. (Eds) The Geology of Norfolk. *Trans. Norfolk Norwich Nat. Soc.* **19** (6), 269–375.

Lecointre, G. 1947. La Touraine. *Géologie régionale de la France* **4,** 250 pp.

—— 1957. Bousse (Sables de . . . , Couches de . . .). P. 64 *in* Sornay, J. (Ed.) France, Belgique, Pays-Bas, Luxembourg; Crétacé. *Lexique Strat. Int.* 1 (4a VI).

—— 1959. Le Turonien dans sa région type: La Touraine. Pp. 415–23 *in* Colloque sur le Crétacé Supérieur français. *C.R. Congr. Socs sav.,* Dijon.

Lee, G. W. & Pringle, J. 1932. A synopsis of the Mesozoic rocks of Scotland. *Trans. geol. Soc. Glasg.* **19,** 158–224.

Lister, M. 1684. *De Fontibus Medicatis Angliae exercitationes duae.* London.

Manning, P. I., Robbie, J. A. & Wilson, H. E. 1970. Geology of Belfast and the Lagan Valley. *Mem. geol. Surv. Nth. Ire.* **36,** 242 pp.

Mantell, G. A. 1818. A sketch of the geological structure of the south-eastern part of Sussex. *Gleaners' Portfolio, or Provincial Magazine,* Lewes, 8.

—— 1822. *The fossils of the South Downs: or illustrations of the geology of Sussex.* Lupton Relfe, London, 327 pp.

—— 1827. *Illustrations of the Geology of Sussex, containing a general view of the Geological relations of the south-eastern part of England, with descriptions of the fossils of Tilgate Forest.* London, 92 pp.

—— 1833. *The Geology of the South East of England.* London, 415 pp.

Markham, R. A. D. 1967. Fossils from the Gipping Valley Chalk, and a note on the Zones. *Bull. geol. Group, Ipswich* **2,** 3–4.

Marks, P. 1967. Foraminifera from the Craie de Théligny (Cenomanian, Dept. Sarthe, France). *Proc. K. ned. Akad. Wet.* **B70,** 425–42.

Martin, E. C. 1932. Chalk Zones in the Foreshore between Worthing and Felpham, Sussex. *Proc. Geol. Ass.* **43,** 201–11.

—— 1938. The Littlehampton and Portsdown Chalk Inliers and their relation to the raised beaches of West Sussex. *Proc. Geol. Ass.* **49,** 198–212.

McGugan, A. 1957. Upper Cretaceous Foraminifera from Northern Ireland. *J. Paleont.* **31,** 329–48.

—— 1974. Cretaceous Foraminifera from Whitepark Bay, Northern Ireland. *Ir. Nat. J.* **18,** 12–17.

Middlemiss, F. A. 1959. English Aptian Terebratulidae. *Palaeontology* **2,** 94–142.

—— 1973. The geographical distribution of Lower Cretaceous Terebratulaceae in Western Europe. Pp. 111–20 *in* Casey, R. & Rawson, P. F. (Eds), *q.v.*

—— & Bromley, R. G. 1963. Field Meeting on the Lower Greensand and Chalk in the Isle of Wight. *Proc. Geol. Ass.* **73,** 449–53.

Moorkens, T. L. 1969. Quelques Globotruncanidae et Rotaliporidae du Cenomanien, Turonien et Coniacien de la Belgique. *Proc. 1st Int. Conf. Planktonic Microfossils,* vol. 2, 435–59.

Morris, J. 1867. On the Ferruginous Sands of Buckinghamshire, with remarks on the distribution of the equivalent strata. *Geol. Mag.* **4,** 456–62.

Moullade, M. & Thieuloy, J. P. 1967. Les zones d'Ammonites du Valanginien supérieur et de l'Hauterivien vocontien. *C.R. somm. Séancs. Soc. géol. Fr.* **6,** 228–29.

Neale, J. W. 1960a. The subdivision of the Upper D Beds of the Speeton Clay of Speeton, East Yorkshire. *Geol. Mag.* **97,** 353–62.

—— 1960b. Marine Lower Cretaceous Ostracoda from Yorkshire, England. *Micropaleontology* **6,** 203–24.

—— 1962a. Ammonoidea from the Lower D Beds (Berriasian) of the Speeton Clay. *Palaeontology* **5,** 272–96.

—— 1962b. Ostracoda from the type Speeton Clay (Lower Cretaceous) of Yorkshire. *Micropaleontology* **8,** 425–84.

—— 1968. Biofacies and lithofacies of the Speeton Clay D Beds, E. Yorkshire. *Proc. Yorks. geol. Soc.* **36,** 309–35.

—— 1973. Ostracoda as means of correlation in the Boreal Lower Cretaceous, with special reference to the British marine Ostracoda. Pp. 169–84 *in* Casey, R. & Rawson, P. F. (Eds), *q.v.*

—— 1974. Cretaceous. Pp. 225–43 *in* Rayner, D. H. & Hemingway, J. E. (Eds) *The Geology and Mineral Resources of Yorkshire.* Yorks. geol. Soc., Leeds.

Obradovich, J. D. & Cobban, W. A. 1975. A time-scale for the Late Cretaceous of the Western Interior of North America. Pp. 31–54 *in* Caldwell, W. G. E. (Ed.), *q.v.*

Orbigny, A. d' 1840–42. *Paléontologie française, Terrhains Crétacés.* 1 *Céphalopodes.* Masson, Paris, 662 pp.

—— 1848–51. *Paléontologie française, Terrains Crétacés. 4. Brachiopodes.* Masson, Paris, 390 pp.

—— 1852. *Cours élémentaire de Paléontologie et de Géologie Stratigraphiques* **2,** 268–947, Paris.

Orlov, Yu. A. (Editor) 1958. *Principles of Palaeontology. 6 Mollusca: Cephalopoda II Ammonoidea (ceratites and ammonites) Endocochlia. (in Russian) Moscow,* 359 pp.

Owen, E. F., Rawson, P. F. & Whitham, F. 1968. The Carstone (Lower Cretaceous) of Melton, East Yorkshire, and its brachiopod fauna. *Proc. Yorks. geol. Soc.* **36,** 513–24.

—— & Thurrell, R. G. 1968. British Neocomian rhynchonelloid brachiopods. *Bull. Br. Mus. nat. Hist.* (Geology) **16,** 99–123.

Owen, H. G. 1958. Lower Gault sections in the northern Weald, and the zoning of the Lower Gault. *Proc. Geol. Ass.* **69,** 148–65.

—— 1971. Middle Albian stratigraphy in the Anglo-Paris Basin. *Bull. Br. Mus. nat. Hist.* (Geology), Suppl. **8,** 164 pp.

—— 1972. The Gault and its junction with the Woburn Sands in the Leighton Buzzard area, Bedfordshire and Buckinghamshire. *Proc. Geol. Ass.* **83,** 287–312.

—— 1976. The stratigraphy of the Gault and Upper Greensand of the Weald. *Proc. Geol. Ass.* **86,** 475–98.

Pavlow, A. P. 1889. Études sur les couches Jurassiques et Crétacées de la Russie. I. Jurassique supérieur et Crétacé inférieur de la Russie et de l'Angleterre. *Byull. mosk. Obshch. Ispyt. Prir.* n.s. **3,** 61–127.

Peach, B. N., Horne, J. Woodward, H. B., Clough, C. T., Harker, A. & Wedd, C. B. 1910. The Geology of Glenelg, Lochalsh and South East part of Skye. *Mem. geol. Surv. Scotland* **71,** 206 pp.

Peake, N. B. & Hancock, J. M. 1961. The Upper Cretaceous of Norfolk. Pp. 293–339 *in* Larwood, G. P. & Funnell, B. M.

(Eds) The Geology of Norfolk. *Trans. Norfolk Norwich Nat. Soc.* **19** (6), 269–375.

—— & —— 1970. *ibid*, reprinted with supplement.

Penny, L. F. & Rawson, P. F. 1969. Field meeting in East Yorkshire and North Lincolnshire. *Proc. Geol. Ass.* **80,** 193–218.

Pinckney, G. & Rawson, P. F. 1974. *Acroteuthis* assemblages in the Upper Jurassic and Lower Cretaceous of northwest Europe. *Newsl. Stratigr.* **3,** 193–204.

Pitcher, W. S., Peake, N. B., Carreck, J. N., Kirkaldy, J. F. & Hancock, J. M. 1967. The London Region (South of the Thames). *Geol. Ass. Guides* **30B**.

Price, F. G. H. 1874. On the Lower Greensand and Gault of Folkestone. *Proc. Geol. Ass.* **4,** 135–50.

—— 1875. On the Gault of Folkestone. *Q. Jl geol. Soc. Lond.* **30,** 342–66.

Pringle, J. & Manson, W. 1934. P. 83 in *Summ. Prog. geol. Surv. for 1933.*

Rance, C. E. de 1868. On the Albian or Gault of Folkestone. *Geol. Mag.* **5,** 163–71.

Rawson, P. F. 1971a. Lower Cretaceous ammonites from north-east England: the Hauterivian genus *Simbirskites. Bull. Br. Mus. nat. Hist.* (Geology) **20,** 25–86.

—— 1971b. The Hauterivian (Lower Cretaceous) biostratigraphy of the Speeton Clay of Yorkshire, England. *Newsl. Stratigr.* **1** (4), 61–75.

—— 1972. A note on the biostratigraphical significance of the Lower Cretaceous belemnite genus *Aulacoteuthis* in the B Beds of the Speeton Clay, Yorkshire. *Proc. Yorks. geol. Soc.* **39,** 89–91.

—— 1973. Lower Cretaceous (Ryazanian–Barremian) marine connections and cephalopod migrations between the Tethyan and Boreal Realms. Pp. 131–44 *in* Casey, R. & Rawson, P. F. (Eds), q.v.

—— 1974. Hauterivian (Lower Cretaceous) ammonites from Helgoland. *Geol. Jb.* **A25,** 55–83.

—— 1975a. The interpretation of the Lower Cretaceous heteromorph ammonite genera *Paracrioceras* and *Hoplocrioceras* Spath, 1924. *Palaeontology* **18,** 275–83.

—— 1975b. Lower Cretaceous ammonites from north-east England: the Hauterivian heteromorph *Aegocrioceras. Bull. Br. Mus. nat. Hist.* (Geology) **26,** 129–59.

Reid, R. E. H. 1971. The Cretaceous Rocks of North-Eastern Ireland. *Ir. Nat. J.* **17,** 105–129.

—— 1973. Origin of the Mesozoic 'Boreal' realm. *Geol. Mag.* **110,** 67–69.

—— 1976. Late Cretaceous climatic trends, faunas and hydrography in Britain and Ireland. *Geol. Mag.* **113,** 115–28.

Renevier, E. 1867. Notices géologiques et paléontologiques sur les Alpes vaudoises et les régions environnantes. V. Complément de la faune de Cheville. *Bull. Soc. vaud. Sci. nat.* **9,** 115–208.

—— 1874. Tableau des terrains sédimentaires. *Bull. Soc. vaud. Sci. nat.* **13,** 218–252.

Rhys, G. H. 1974. A proposed standard lithostratigraphic nomenclature for the southern North Sea and an outline structural nomenclature for the whole of the (UK) North Sea. *Rep. Inst. Geol. Sci.* **74/8,** 14 pp.

Rogers, I. & Simpson, B. 1937. The flint gravel deposit of Orleigh Court, Buckland Brewer, north Devon. *Geol. Mag.* **74,** 309–16.

Rowe, A. W. 1900–1908. The Zones of the White Chalk of the English Coast. *Proc. Geol. Ass.* **16** (1900), 289–368; **17** (1902), 1–76; **18** (1903), 1–51, (1904), 193–296; **20** (1908), 209–352.

—— 1929. The Zones of the White Chalk of Lincolnshire. *Naturalist* (for 1929) 411-39.

Saks, V. N. (Editor) 1972. *The Jurassic-Cretaceous boundary and the Berriasian stage in the Boreal Realm.* Nauka, Novosibirsk, 371 pp. (In Russian: English translation published by I.P.S.T., Jerusalem, 1975).

Sarkar, S. S. 1955. Révision des ammonites déroulées du Crétacé inférieur du Sud-est de la France. *Mém. Soc. géol. Fr.* **72,** 176 pp.

Sazonov, N. T. 1951. On some little-known ammonites of the Lower Cretaceous. *Byull. mosk. Obshch. Ispyt Prir.* **56,** 57–63 (in Russian).

Schlüter, C. 1871–6. Cephalopoden der

oberen deutschen Kreide. *Palaeontographica* **21,** 1–24 (1871), 25–120 (1872); **24,** 121–264 (1876).

SCHMID, F. 1956. Jetziger Stand der Oberkreide-Biostratigraphie in Nordwestdeutschland: Cephalopoden. *Paläont. Z.* **30,** 7–10.

—— 1959. La définition des limites Santonien–Campanien et Campanien inférieur-supérieur en France et dans le nord-ouest de l'Allemagne. Pp. 535–46 *in* Colloque sur le Crétacé Supérieur franąis. *C.R. Congr. Socs sav.*, Dijon.

—— 1965. *Actinocamax plenus* (Blainville), ein seltener Belemniten-Fund im Rotpläner (Oberkreide, Niedersachsen). *Geol. Jb.* **83,** 517–32.

—— 1967. Die Oberkreide-Stufen Campan und Maastricht in Limburg (Südniederlande, Nordostbelgien), bei Aachen und in Nordwest-deutschland. *Ber. dt. Ges. geol. Wiss., A. Geol. Paläont.* **12,** 471–78.

——, HILTERMANN, H. & KOCH, W. 1955. Biostratigraphie der Grenzschichten Maastricht/Campan in Lüneburg und in der Bohrung Brunhilde. *Geol. Jb.* **70,** 339–84.

SEITZ, O. 1956. Über Ontogenie, Variabilität und Biostratigraphie einiger Inoceramen. *Paläont. Z.* **30,** 3–6.

SELWOOD, E. B. et al. (*in press*). The Geology of the Country around Newton Abbot. *Mem. geol. Surv. Gt Br.*

SÉRONIE-VIVIEN, M. 1956. *Étude du Crétacé supérieur de la vallée de l'Isle.* Diplôme Études Sup., Univ. Bordeaux.

—— 1959. Les localités-types du Senonien dans les environs de Cognac et de Barbezieux (Charente). Pp. 579–89 *in* Colloque sur le Crétacé Supérieur français. *C.R. Congr. Socs sav.*, Dijon.

—— 1972. Contribution à l'étude de Sénonien en Aquitaine septentrionale, ses stratotypes: Coniacien, Santonien, Campanien. *Les Stratotypes Français* **2,** *Édit, Centre Natl Rech. Sci.*, 195 pp.

SMART, J. G. O., BISSON, G. & WORSSAM, B. C. 1966. Geology of the country around Canterbury and Folkestone. *Mem. geol. Surv. Gt Br.*, 337 pp.

—— & WOOD, C. J. 1976. (Field meeting to) South Humberside. *Proc. Yorks. geol. Soc.* **40,** 586–93.

SMITH, A. J. & CURRY, D. 1975. The structure and geological evolution of the English Channel. *Phil Trans. R. Soc.* **A279,** 3–20.

——, STRIDE, A. H. & WHITTARD, W. F. 1965. The geology of the Western Approaches of the English Channel. IV: A recently discovered Variscan granite west-north-west of the Scilly Isles. *Colston Pap.* **17,** 287–301.

SMITH, W. E. 1961. The Cenomanian Deposits of South-East Devonshire. The Cenomanian Limestone and Contiguous Deposits West of Beer. *Proc. Geol. Ass.* **72,** 91–134.

SORNAY, J. 1957. Crétacé: France, Belgique, Pays-Bas, Luxembourg. *Lexique Strat. Int.* 1 (4a VI), 403 pp.

—— 1959. Les formes d'Inocérames du Crétacé Supérieur en France. Pp. 661–69 *in* Colloque sur le Crétacé Supérieur français. *C.R. Congr. Socs sav.*, Dijon.

SPAETH, C. 1971. Untersuchungen an Belemniten des Formenkreises um *Neohibolites minimus* (Miller 1826) aus dem Mittel- und Ober-Alb Nordwestdeutschlands. *Beih. geol. Jb.* **100,** 127 pp.

—— 1973. *Neohibolites ernsti* and its occurrence in the Upper Albian of northwest Germany and England. Pp. 361–68 *in* CASEY, R. & RAWSON, P. F. (Eds), *q.v.*

SPATH, L. F. 1923. On the ammonite horizons of the Gault and contiguous deposits. *Summ. Progr. geol. Surv. U.K.* for 1922, 139–49.

—— 1924. On the ammonites of the Speeton Clay and the subdivisions of the Neocomian. *Geol. Mag.* **61,** 73–89.

—— 1926. On the zones of the Cenomanian and the uppermost Albian. *Proc. Geol. Ass.* **37,** 420–32.

—— 1941. A monograph of the Ammonoidea of the Gault. Pt 14. *Palaeontogr. Soc.* [*Monogr.*], 609–68.

—— 1943. A monograph of the Ammonoidea of the Gault. Pt 16. *Palaeontogr. Soc.* [*Monogr.*], 721–87.

SRIVASTAVA, S. K. 1975. Maastrichtian microspore assemblages from the interbasaltic lignites of Mull, Scotland. *Palaeontographica* ser. B, **150,** 125–56.

STINTON, F. C. 1971. Easter field meeting in the Isle of Wight. *Proc. Geol. Ass.* **82,** 403–10.

STOKES, R. B. 1975. Royaumes et provinces fauniques du Crétacé établis sur la base d'une étude systématique du genre *Micraster. Mém. Mus. natn Hist. nat., Paris* (C) **31,** 94 pp.

STOLLEY, E. 1908. Die Gliederung der Norddeutschen Unteren Kreide. *Zentbl. Miner. Geol. Paläont.* 1908, 107–24, 140–51, 162–72, 211–20, 242–47.

STRAHAN, A. 1886. Notes on the relations of the Lincolnshire Carstone. *Q. Jl geol. Soc. Lond.* **42,** 486–93.

—— 1891. On a Phosphatic Chalk with *Belemnitella quadrata* at Taplow. *Q. Jl geol. Soc. Lond.* **47,** 356–67.

SURLYK, F. 1970. Die Stratigraphie des Maastricht von Dänemark und Norddeutschland aufgrund von Brachiopoden. *Newsl. Stratigr.* **1** (2), 7–16.

—— 1973. The Jurassic-Cretaceous boundary in Jameson Land, East Greenland. Pp. 81–100 *in* CASEY, R. & RAWSON, P. F. (Eds), *q.v.*

SWINNERTON, H. H. 1935. The rocks below the Red Chalk of Lincolnshire and their Cephalopod faunas. *Q. Jl geol. Soc. Lond.* **91,** 1–46.

—— 1936–55. A monograph of British Lower Cretaceous Belemnites. *Palaeontogr. Soc.* [*Monogr.*] 86 + xl pp.

—— 1941. Further observations on the Lower Cretaceous rocks of Lincolnshire. *Proc. Geol. Ass.* **52,** 198–207.

—— & KENT, P. E. 1949. *The Geology of Lincolnshire.* Lincs. Natural History Brochures, no. 1. Lincs. Naturalists' Union, 126 pp.

TAIT, D. 1909. On the Occurrence of Cretaceous Fossils in Caithness. *Trans. Edinb. geol. Soc.* **9,** 318–21.

TAITT, A. H. & KENT, P. E. 1958. *Deep boreholes at Portsdown (Hants) and Henfield (Sussex).* B.P. Co., Ltd., Technical publication. 41 pp.

TAYLOR, J. C. M. 1959. The clays and heavy minerals of the Shotover Ironsand Series. *Proc. Geol. Ass.* **70,** 239–53.

THIERMANN, A. 1963. Die Ammonitengattung *Endemoceras* n. g. aus dem Unter-Hauterive von Nordwest-Europa. *Geol. Jb.* **81,** 345–412.

THIEULOY, J-P. 1973. The occurrence and distribution of boreal ammonites from the Neocomian of southeast France (Tethyan Province). Pp. 289–302 *in* CASEY, R. & RAWSON, P. F. (Eds), *q.v.*

THURRELL, R. G., WORSSAM, B. C. & EDMONDS, E. A. 1968. Geology of the country around Haslemere. *Mem. geol. Surv. Gt Br.*, 169 pp.

TOUCAS, A. 1888. Note sur le Jurassique supérieur et le Crétacé inférieur de la vallée du Rhône. *Bull. Soc. géol. Fr.* (3) **16,** 903–27.

TOWNSON, W. G. 1975. Lithostratigraphy and deposition of the type Portlandian. *Jl geol. Soc. Lond.* **131,** 619–38.

TREACHER, L. & WHITE, H. J. O. 1906. The Higher Zones of the Upper Chalk in the Western Part of the London Basin. *Proc. Geol. Ass.* **19,** 378–99.

TRESISE, G. R. 1960. Aspects of the Lithology of the Wessex Upper Greensand. *Proc. Geol. Ass.* **71,** 316–39.

TRIGER, J. 1869. Divisions générales de la carte géologique de la Sarthe: terrain crétacé. (Tabular plate). *In* COTTEAU, G. & TRIGER, J. 1855–69 *Echinides du département de la Sarthe.* Baillière, Paris, 456 pp.

TRÖGER, K. A. 1967. Zur Paläontologie, Biostratigraphie und faziellen Ausbildung der unteren Oberkreide (Cenoman bis Turon). Teil I. *Abh. Staatl. Mus. Mineral. Geol. Dresden* **12,** 13–207.

—— 1968. Zur Bedeutung ökologischer Faktoren für die Leitfossilien des Obercenoman-Unterturon-Zeitabschnitts in Mitteleuropa. *Geologie* **17,** 68–75.

—— & HALLER W. 1966. Biostratigraphie der Inoceramen und einiger ausgewählter ammoniten, belemniten und echinodermaten des unter-Coniac bis unter-Campan in der DDR. *Abh. zentr. geol. Inst.* **5,** 84–91.

UHLENBROEK, G. D. 1911. Het Krijt Van Zuid-Limburg (Toelichting bij eene Geologische Kaart van het Krijtgebied van Zuid-Limburg). *Jversl. Rijksopspor. Delfstoff.* 1911, 48–57.

VENABLES, E. M. 1931. Notes on the Geology of Felpham, near Bognor Regis. *Proc. Geol. Ass.* **42,** 362–69.

—— 1932. Note on the Chalk of Felpham. *Proc. Geol. Ass.* **43,** 223–24.

VOIGT, E. 1956. Zur Frage der Abgrenzung der Maastricht-Stufe. *Paläont. Z.* **30,** 11–17.

WARD, W. H., BURLAND, J. B. & GALLOIS, R. W. 1968. Geotechnical assessment of a site at Mundford, Norfolk, for a large Proton Accelerator. *Géotechnique* **18,** 399–431.

WHITE, H. J. O. 1907. The Geology of the Country around Hungerford and Newbury. *Mem. geol. Surv. Eng. Wales,* 150 pp.

—— 1921. A short account of the Geology of the Isle of Wight. *Mem. geol. Surv. Gt Br.* 219 pp.

—— 1923. The Geology of the Country south and west of Shaftesbury. *Mem. geol. Surv. Gt Br.* 112 pp.

—— 1924. The Geology of the Country near Brighton and Worthing. *Mem. geol. Surv. Gt Br.,* 114 pp.

—— 1926. The Geology of the Country near Lewes. *Mem. geol. Surv. Gt Br.,* 97 pp.

—— 1928. The Geology of the Country near Hastings and Dungeness. *Mem. geol. Surv. Gt Br.,* 104 pp.

—— 1932. The Geology of the Country near Saffron Walden. *Mem. geol. Surv. Gt Br.,* 125 pp.

—— & TREACHER, L. 1905. On the Age and Relations of the Phosphatic Chalk of Taplow. *Q. Jl geol. Soc. Lond.* **61,** 461–94.

WILLCOX, N. R. 1953. Zonal variations in selected morphological features of *Echinocorys scutata* Leske. *Geol. Mag.* **90,** 83–96.

WILLIAMS, G. D. & BAADSGAARD, H. 1975. Potassium-argon dates and Upper Cretaceous biostratigraphy in eastern Saskatchewan. Pp. 417–26 *in* CALDWELL, W. G. E. (Ed.), *q.v.*

WILLIAMS-MITCHELL, E. 1948. The zonal value of Foraminifera in the Chalk of England. *Proc. Geol. Ass.* **59,** 91–112.

WILSON, H. E. 1972. *Regional Geology of Northern Ireland.* Geol. Surv. N. Ireland, 115 pp.

WILSON, V. 1948. *East Yorkshire and Lincolnshire.* British Regional Geology, H.M.S.O., 94 pp.

——, WELCH, F. B. A., ROBBIE, J. A. & GREEN, G. W. 1958. Geology of the Country around Bridport and Yeovil. *Mem, geol. Surv. Gt Br.,* 239 pp.

WOOD, C. J. 1965. Field meeting on the Lower Chalk between Folkestone and Dover. *Proc. Geol. Ass.* **76,** 301–4.

—— 1967. Some new observations on the Maestrichtian Stage in the British Isles. *Bull. geol. Surv. Gt Br.* **27,** 271–88.

—— 1974. P. 117 in *Ann. Rep. Inst. geol. Sci.* for 1973. H.M.S.O. London.

—— & FLETCHER, T. P. *in press.* In WILSON, H. E. & MANNING, P. I. Geology of the Causeway Coast. *Mem. geol. Surv. Nth. Ire.*

WOODLAND, A. W. (Editor) 1975. *Petroleum and the Continental Shelf of North West Europe. Volume 1 Geology.* Applied Science Publishers Ltd., Barking, 501 pp.

WOODS, H. 1896. The Mollusca of the Chalk Rock. Pt. I. *Q. Jl. geol. Soc. Lond.* **52,** 68–98.

—— 1897. The Mollusca of the Chalk Rock. Pt II. *Q. Jl geol. Soc. Lond.* **53,** 377–404.

WORSSAM, B. C. 1963. Geology of the Country around Maidstone. *Mem. geol. Surv. Gt Br.,* 152 pp.

—— & IVIMEY-COOK, H. C. 1971. The stratigraphy of the Geological Survey borehole at Warlingham, Surrey. *Bull. geol. Surv. Gt Br.* **36,** 1–111.

—— & TAYLOR, J. H. 1969. Geology of the Country around Cambridge. *Mem. geol. Surv. Gt Br.,* 159 pp.

—— & THURRELL, R. G. 1967. Field meeting to an area north of Horsham, Sussex. *Proc. Geol. Ass.* **77,** 263–71.

WRIGHT, C. W. *in press.* The ammonites of the English Chalk Rock (Upper Turonian). *Bull. Br. Mus. nat. Hist.* (Geology).

—— & WRIGHT, E. V. 1942. The Chalk of the Yorkshire Wolds. *Proc. Geol. Ass.* **53,** 112–27.

—— & —— 1951. A survey of the fossil Cephalopoda of the Chalk of Great Britain. *Palaeontogr. Soc.* [*Monogr.*], 41 pp.

YANSHIN, A. L. 1960. Stratigraphic position of the Danian stage and the problem of the Cretaceous–Paleogene boundary. *Int. Geol. Congr., 21st. Norden, Rept.* pt 5, 210–15.

Ziegler, P. A. 1975. North Sea Basin History in the Tectonic Framework of North-Western Europe. Pp. 131–49 *in* Woodland, A. W. (Ed.), *q.v.*

Peter Franklin Rawson, B.Sc., Ph.D., F.G.S. Department of Geology, Queen Mary College (University of London), Mile End Road, London E1 4NS.
Dennis Curry, M.A., F.G.S. Department of Geology, University College London, Gower Street, London WC1E 6BT.
Frank Charles Dilley, M.Sc. British Petroleum Co. Ltd., Ropemaker Street, London EC2Y 9BU.
John Michael Hancock, M.A., Ph.D., F.G.S. Department of Geology, Kings College London, Strand, London WC2R 2LS.
William James Kennedy, M.A., B.Sc., Ph.D., F.G.S. Department of Geology, University Museum, Parks Road, Oxford, OX1 3PR.
John William Neale, B.Sc., Ph.D., D.Sc., F.G.S., F.L.S. Department of Geology, The University, Hull, North Humberside, HU6 7RX.
Christopher John Wood, B.Sc., F.G.S. Institute of Geological Sciences, Exhibition Road, London SW7 2DE.
Bernard Charles Worssam, B.Sc., F.G.S. Institute of Geological Sciences, 5 Princes Gate, London SW7 1QN.

Special Report No. 6

A CORRELATION OF THE PRECAMBRIAN ROCKS IN THE BRITISH ISLES

by

HARRIS, A. L., SHACKLETON, R. M., WATSON, J., DOWNIE, C., HARLAND, W. B. & MOORBATH, S.

This report comprises a collection of articles on every aspect of the stratigraphy of the Precambrian rocks of the British Isles, including the Scottish successions, the Precambrian basement of England, Wales and southeast Ireland, Precambrian rocks within the Hercynides, isotopic dating and palaeontology. There is an extensive bibliography.

SBN 7073 0112 2 Price £6.00

Special Report No. 8

A CORRELATION OF THE DEVONIAN ROCKS IN THE BRITISH ISLES

by

HOUSE, M. R., RICHARDSON, J. B., CHALONER, W. G., ALLEN, J. R. L., HOLLAND, C. H. & WESTOLL, T. S.

This report gives a detailed account of the classic marine Devonian and Old Red Sandstone successions of the British Isles, including the subsurface Devonian of southeast England. Each area is illustrated by a correlation chart. There is an extensive bibliography.

SBN 7073 0121 1 Price £6.00

Special Report No. 9: CRETACEOUS Price £5.00 ($13.50) SBN 7073 0221 8

Published by Scottish Academic Press Ltd., Edinburgh
Printed by The Universities Press, Belfast