THE STRATIGRAPHICAL PALAEONTOLOGY OF THE LOWER GREENSAND

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CONTENTS

ABSTRACT. The Lower Greensand in Britain comprises up to 800 feet of sediments laid down in a great variety of near-shore environments stretching from the Isle of Wight northwards to the border of Yorkshire. The fauna is dominantly molluscan, of neritic, littoral, and estuarine facies, with local abundance of brachiopoda, polyzoa, or sponges. Despite losses from subsequent leaching, it is unexpectedly rich; the ammonite sequence is known in unrivalled detail and affords a basis for division of the Aptian and Lower Albian Stages of the Lower Cretaceous into nine zones and twenty-four subzones. The whole fauna and flora of the Lower Greensand (microzoa excepted) is listed with up-to-date names in the new zones and the application of the zonal scheme in the field is demonstrated in a detailed description of the stratigraphy and life-succession region by region. Revised correlations of the various local subdivisions of the Lower Greensand are set out in diagrams and tables. The depositional history of the formation is reviewed, bringing out new information which has resulted from use of a refined ammonite chronology. New taxa described in the systematic section are: Gastropods, 1 genus, 2 species; Lamellibranchs, 1 family, 8 genera, 20 species; Ammonites, 3 genera, 14 species; Brachiopods, 1 genus, 1 species; Polyzoa, 1 species; Problematica, 2 genera, 1 species. Many species are recorded from the Lower Greensand for the first time. Genera new to the British Cretaceous are the lamellibranchs *Disparilia*, *Senis*, *Cuneocorbula*, *Eomiodon*, and *Protodonax*, the ammonite *Megatyloceras*, and the boring polyzoan *Graysonia*. *Eomiodon* and *Protodonax* occur in the Aptian of the Middle East but have not been recorded previously from the Cretaceous of Europe.

INTRODUCTION

THE Lower Greensand is a series of sandy deposits underlying the Gault and occupies extensive tracts of country in southern England, reaching a thickness of 800 feet in the Isle of Wight. It provides the most complete record of the Aptian and Lower Albian stages of the Lower Cretaceous in Britain and marks the beginning of a great cycle of marine sedimentation that continued until the end of the Mesozoic.

Historical accounts of the Lower Greensand will be found in Mantell (1822), Conybeare and Phillips (1822), Fitton (1824, 1836, 1847*a*, *b*), Mantell (1851), Topley (1875), Bristow (1889), Jukes-Browne (1900; 1911), Stopes (1915), Boswell (1929), and Kirkaldy

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(1939), and fuller references to the literature are given by Stopes (1915), Kirkaldy (1939), and Casey (1960*a*).

Interest in the stratigraphical palaeontology of the Lower Greensand was at its height in the early part of the last century: Fitton, Bensted, and others were then active in the field and the Sowerbys, Forbes, Mantell, and Morris were busy naming and describing the fossils. Such team work among the field men and the palaeontologists was never repeated and succeeding generations of palaeontologists found themselves more and more out of touch with the Lower Greensand. Already by 1854 Sharpe found the fossils of the Faringdon Sponge Gravels, a local facies of the formation, so foreign to his idea of a Lower Greensand fauna that he declared them to be of Danian age. Later Kitchin and Pringle (1921) refused to believe that fossils collected by Lamplugh and Walker (1903) from the top of the Lower Greensand at Leighton Buzzard belonged even to the Lower Cretaceous and went to extraordinary lengths trying to prove that the whole of the Gault and its superstratum had been turned upside-down. Scepticism has also been voiced about the provenance of the flowering plants described from the Lower Greensand (Harris 1956) and it is only a few years ago that the ammonites of this formation—now known to give an unrivalled sequence through Aptian and Lower Albian times—had been written off as an 'impoverished' set by the experts (Spath 1930*a*; Arkell 1947*b*).

Not only in the ammonites, but in many other groups of Lower Greensand fossils, poverty turns to riches with patience. These riches are the natural legacy of a formation laid down in changing coastal waters. The Faringdon Sponge Gravels, the Shenley Limestone, the Iron Sands of Seend, the Crackers, the Punfield Marine Band, the *regularis-mammillatum* nodule-beds—these and many more reflect marine environments of a diversity and individuality difficult to match in any other formation the world over.

The present memoir is really a corollary to my *Monograph of the Ammonoidea of the Lower Greensand* (Part 1, Casey 1960*a*) and was first written as a stratigraphical review of the Lower Greensand with special regard to ammonite occurrences. The importance of ammonites for zoning and correlation makes such emphasis inevitable, but to make the paper more useful I have tried to give an up-to-date account of the whole fauna. The need for systematic work on all its animal-groups is patently obvious to anyone who has to name Lower Greensand fossils. Woods's great monograph on the Cretaceous Lamellibranchia was written fifty years ago and it is not surprising that many more species have been found since and that the names of others need revising. Except for a recent paper by Cox (1960) on the family Pleurotomariidae, work on Lower Greensand gastropods seems to have ceased from the time of Starkie-Gardner (1875–7). Elliott (1947; 1959), Middlemiss (1959), and Owen (1956; 1960) have made a start on revising the brachiopods, so well described by Davidson (1851–86) and Walker (1867–70) in the last century, but for the corals, echinoids, and sponges we still rely largely on the works of Duncan (1866–91), T. Wright (1864–82), and Hinde (1883; 1885) respectively. Papers by Chapman (1894) and J. Wright (1905) are still the last words on the microzoa. The only group of fossils in the Lower Greensand that has received adequate attention is the plants, mostly drift-wood, which was the subject of illuminating work by the late Dr. Marie Stopes (1911–15).

Aside from the restudy of museum specimens, there is a greater need for fresh material gathered first-hand from the field. Much of the Lower Greensand consists of sands more or less leached of organic matter and real advances in the study of the faunal sequence depend on the finding at new levels of hard nodules or lenses in which fossils have escaped dissolution. All that can be accomplished today is an interim stocktaking of the fauna to show what groups are most badly in need of specialist attention and where search in the field should be redoubled.

The following pages contain the results of some twenty-five years' work on the Lower Greensand as a leisure-time pursuit. During that time I have received the help of a large number of collectors and enthusiasts. In addition to those friends named on a previous occasion (Casey 1960*a*, pp. ii–iii), I am indebted to Miss Eileen Andrews for assistance with some of the diagrams. Dr. W. G. Chaloner and Mr. C. W. Wright have been especially helpful in providing information and I have had the benefit of advice from many of my colleagues at the Geological Survey and the British Museum (Natural History). Some of the work was done in the Geology Department of the University of Reading during a period of leave granted me by the Department of Scientific and Industrial Research. Geological Survey photographs are reproduced by permission of the Controller, H.M. Stationery Office, and the paper is published by permission of the Director, Geological Survey and Museum. Funds for publication were provided by Shell International Research.

STRATIGRAPHICAL RELATIONS OF THE LOWER GREENSAND

It is traditional for those who write about the Lower Greensand to repeat the gibe that the formation is seldom green and frequently not sand. How this misnomer came to be accepted for a primary division of the British Cretaceous System is a matter of historical interest and is fully explained by Jukes-Browne (1900, pp. 15–26). When the term 'Greensand' was first introduced is a little uncertain, though it is thought to have originated with William Smith between the years 1800 and 1812. What is certain is that both he and Thomas Webster always used it for the green sands between the Chalk and the Gault and not for the sands that underlie the Gault. Misapprehension of the position of the 'Greensand' by William Phillips and Mantell led to much confusion and controversy until it was realized that there were two sandy formations, one above and one below the Gault. 'Reigate Sands', 'Shanklin Sands', 'Ferruginous Sands', 'Carstone', and other terms had come into use for the lower member, but the wide circulation enjoyed by Mantell's books had helped to implant the word 'Greensand' too deeply for it to be uprooted. 'Lower Greensand' and 'Upper Greensand' was the obvious nomenclatorial compromise, for which Webster (1825) accepted responsibility.

Attempts to fit the Lower Greensand into d'Orbigny's scheme of stages provoked another lively controversy about the term 'Neocomian', in which Fitton, Leymerie, Cornuel, Judd, and others joined. It is now known that the true Lower Greensand, as found in the Weald and the Isle of Wight, is of Aptian and Lower Albian age and is younger than the Sandringham Sands, Claxby Beds, and other Neocomian strata to which the name Lower Greensand was loosely applied in the past. The terms 'Vectine' (Fitton 1845) and 'Vectian' (Jukes Browne 1886), proposed for use in an adjectival sense or as a stage name for the Lower Greensand Series, have not been adopted. Defunct names of continental origin which have been applied in the past to parts of the Lower Greensand or with which parts of the Lower Greensand have been correlated are 'Rhodanian' and 'Urgonian'. The first was proposed by Renevier (1854) for a neritic, *Orbitolina* facies of the Aptian developed at Perte-du-Rhône (Ain), France; the second name was given by d'Orbigny (1847*a*) to a calcareous facies of the Barremian (topmost Neocomian) rich in rudists and *Orbitolina* and seen typically at Orgon, southern France.

Relations with the Wealden Beds. In south-east England the Lower Greensand rests on a thick series of fresh- and brackish-water sediments, the Wealden Beds, of which the topmost member is the Weald Clay (Wealden Shales in the Isle of Wight). With rare exceptions, wherever the two formations are seen in contact the junction is absolutely sharp and there are signs in places that deposition of the Lower Greensand was preceded by gentle folding and erosion of the Wealden Beds. At the western end of the Weald, south-west of Haslemere and west of Fernhurst, the base of the Lower Greensand oversteps various marker bands in the Weald Clay (Holmes 1959) and the same type of contact on a much smaller scale was seen by Kirkaldy (1937, p. 106) at Berwick, near Lewes, East Sussex. Another local unconformity has been noted at Kingsnorth, near Ashford, Kent (Edmunds 1956, p. 32). In general, however, the relation of the Lower Greensand to the Wealden Beds is that of disconformity rather than unconformity. In the Isle of Wight, for example, the formation begins with a line of grit full of fish-teeth and other debris washed from the top of the Wealden Shales; but here the bedding of the two formations is strictly parallel and the absence of angular discordance is proved by the persistence of the Wealden Shales at the top of the Wealden Beds both in the Isle of Wight and on the mainland to the east and to the west. The old idea that the Oxford Wealden is a non-marine facies of the Lower Greensand has been disproved (Arkell 1944), but it may now be shown that on the Dorset coast, between Lulworth Cove and Swanage, Wealden conditions lingered on in the estuary of a Lower Greensand river. And here the junction is gradational.

Palaeontology gives no indication of a lengthy break at this level. Although there is a great change in fossils at the base of the Lower Greensand, the fauna of the Wealden Shales and the Weald Clay shows an increasing saltwater influence as one ascends the succession. The highest part of the Wealden is of near-marine facies, comparable with that of the 'Cinder Bed' of the Purbeck, and contains foraminifera, echinoid spines, and the molluscs *Cassiope*, *Ostrea*, *Corbula*, *Nemocardium*, and *Filosina*. The last is a marine-brackish lamellibranch generally mistaken for the fresh-water-brackish *Neomiodon* (or '*Cyrena*') and is common enough in places to be a rock-builder (Casey 1955*a*). It is found also in the Aptian of the Lebanon ('*Corbicula*' *hamlini* Whitfield) and in the Upper Barremian of the Paris Basin ('*Cyclas*' *neocomiensis* Cornuel). *Nemocardium* (*Pratulum*) *ibbetsoni* (Forbes) is another species common to the Upper Barremian of the Paris Basin and the top beds of the English Wealden. Ammonites found a few inches above the bottom of the Lower Greensand indicate an horizon just above the base of the Aptian, and although no correlation of the Wealden Beds with the marine succession can yet be made with certainty, what little evidence there is favours an Upper Barremian age for the topmost beds.[1] This supports Allen's idea that the

[1] Hughes (1958), working on plant spores, puts the Wealden Shales in the Aptian, but since he also correlates them with part of the Fulletby Series it is clear that he is using the term Aptian in Spath's sense of including the *recticostatus* Zone, here reinstated in the Barremian. Derived Kimmeridgian *Pavlovia* occur both in the Lower Greensand and in the top of the Wealden Shales. One badly rolled

top of the Wealden Beds is not much older than the Lower Greensand (Allen 1955, p. 272) and accords with the views of Strahan and Reid (*in* Bristow 1889, p. 19): 'That the change in sediment is such as might have been produced by the sudden conversion of a partially land-locked estuary or lake into a bay open to the sea, whether by subsidence or by washing away a barrier.'

Derived fossils in the Lower Greensand Woburn (= Potton) Sands are supposed to afford evidence of the former extension of the Wealden Beds north of the London Ridge, this supposition dating from Walker's (1866*a*) discovery of water-worn *Iguanodon* bones at Potton. No one would today accept these finds as proof of a Wealden origin: *Iguanodon* was still living in Aptian times and worn fossils are commonplace in contemporary Lower Greensand deposits (see Keeping 1883, p. 40). Equally unsatisfactory are the 'Potton' plants said to have originated in the Wealden. In an appendix to her catalogue of the Lower Greensand flora Stopes (1915) described the following cycadophytes from the 'Potton Sands' as probable Wealden derivatives: *Cycadeoidea yatesii* (= *Yatesia morrisi*), *C. buzzardensis*, *Bennettites inclusus*, and *Colymbetes edwardsi*, the last attributed to Potton with question. Said Stopes (1915, p. 295): 'It is generally held that Potton fossils of the colour and texture of these (rich red-brown limonite) are derived from the Wealden.' Teall (1875) made a study of the Potton fossils and had concluded just the opposite: he thought the ferruginous fossils were indigenous and specifically stated (p. 9) that the cycadophytes ought not to be regarded as derived. The 'tree-fern' *Tempskya* (= *Endogenites*) *erosa*, which Teall looked upon as a Wealden fossil at Potton, was included by Stopes in the native flora. There is a similar sharp divergence of opinion about the pine-cone *Pinostrobus cylindroides*. Gardner (1886) vouched for it as a Lower Greensand fossil, finding it 'in excellent condition, certainly not derived from any older beds, like so many of the Potton fossils'. Seward's (1895, p. 193) inspection of the same fossil led him 'to unhesitatingly describe it as distinctly worn and rolled, and imperfectly preserved . . .'. Stopes did not examine the original of the unique *Bennettites inclusus* (in the York Museum) and the source of *Colymbetes edwardsi* is unknown; of the species cited in her appendix, it is therefore on the *Cycadeoidea* that the question of provenance really hinges. Carruthers (1870) had misleadingly described these as having been found in the same stratum as the cone *Cycadeostrobus walkeri*, i.e. the Potton nodule-bed. In fact they were obtained from Leighton Buzzard, 'near Leighton Buzzard' or 'sandpit just outside Leighton Buzzard'. I have examined fifteen specimens in the British Museum (Natural History) and the Geological Survey Museum so labelled. All are in heavy dark reddish-brown carstone, the largest (BM. V 13238) weighing several pounds. They are not distinguishable in appearance from the carstone concretions with fossil wood that occur near the top of the 'Silver Sands' in the Leighton Buzzard pits in work today, from which horizon they may well have originated (see Lamplugh and Walker 1903, p. 239). A century ago, before *Bennettites* had been described from the Aptian, a cycad-like plant in the Lower Cretaceous may have raised the presumption of a Wealden age. Today it is not so easy to believe that these fossils are derived. Indigenous or derived, plant and reptile, none of these fossils gives grounds for supposing that the Wealden Beds of south-east England

specimen was sent to me as an uncoiled ammonite, thereby suggesting a solution to the puzzling record of *Ancyloceras* in the Wealden Shales (Judd 1871, p. 220). This should not deter anyone from searching for drifted Barremian ammonites in the quasi-marine beds at the top of the Wealden.

stretched north into Bedfordshire. They suggest simply that sometime in the Lower Cretaceous the northern slopes of the London Ridge supported *Iguanodon* and a flora with cycadophytes and 'tree-ferns', which is what one would expect whether the waters that lapped against the Ridge were salt or fresh. The apparent absence of Wealden fossils of aquatic type among the Potton derivatives favours the idea that these plants and reptile remains were washed straight from the land into the sea.

Relations with other subjacent formations. Extending westwards beyond the Weald the Lower Greensand oversteps the Wealden Beds and passes across various members of the Jurassic System. North of the buried London Ridge it rests on Jurassic or marine Neocomian rocks, and borings along the edge of the Ridge show that in places it laps on to the Palaeozoic (e.g. at Lowestoft). In these regions there is no problem about delimiting the base of the Lower Greensand.

Relations with the Gault. Fitton (1836) and Topley (1868) knew that in the field it is often difficult to draw a rigid dividing-line between the Lower Greensand and the Gault. In Norfolk and Lincolnshire, where the Gault may pass laterally into 'Red Chalk', there is a similar gradational junction. Later workers were impressed by the seemingly abrupt introduction of Albian fossils in the transgressive beds at the base of the Gault and thought there was an unconformity at this horizon, which in Britain had been taken as the plane of division between the Lower and the Upper Cretaceous. Eventually Albian fossils were found to range well down into the Lower Greensand, showing that the base-line of the Gault does not mark any important break or boundary in the geological time-scale; it is, in fact, diachronous and often arbitrary (Casey 1950). Generally speaking the change from predominantly sandy to predominantly clayey sediment takes place within a few feet of condensed strata of *mammillatum* Zone age; exceptionally, as in the extreme east of Sussex, these passage-beds reach down to the top of the Aptian; commonly, as in the Isle of Wight, they extend up into the *dentatus* Zone. In these circumstances a workable boundary can be fixed only by palaeontology. For the purposes of this paper, as in my *Monograph of the Ammonoidea of the Lower Greensand*, the upper limit of the Lower Greensand is drawn at the top of the *mammillatum* Zone. As thus defined, the formation corresponds exactly to the Aptian and Lower Albian stages of international nomenclature.

ZONATION OF THE LOWER GREENSAND

The terms Aptian and Albian are anglicized versions of d'Orbigny's 'Aptien' and 'Albien', the former named from the village of Apt (Basses-Alpes), the latter from the district of the Aube, south of the Paris Basin (d'Orbigny 1840; 1842*a*). During the past 120 years numerous schemes have been proposed for subdividing these stages or for altering their limits in a Procrustean manner to suit local requirements. Most of the pioneer work in zonation was carried out in south-east France and north Germany and it is from these two regions that much of present-day nomenclature derives.

Separation of the Aptian of south-east France into two broad divisions, an upper portion typified by the marls in the neighbourhood of Apt, near Gargas (Basses-Alpes), and a lower portion represented by the limestones of La Bédoule, near Marseilles, is of long standing and was made already by Ewald (1850). These two divisions, the lower characterized by *Ammonites deshayesi* and *Ancycloceras matheronianum* d'Orbigny, the upper by *Ammonites dufrenoyi*, *A. martini*, and *A. nisus* d'Orbigny, were ranked as substages by Dumas (1876) and it was to these substages that the terms Bedoulian and Gargasian were subsequently applied by Toucas (1888) and Kilian (1887) respectively. By the end of the nineteenth century a considerable body of information on the local stratigraphy and sequence of faunas in the Aptian and Albian of south-east France had accumulated, but it was not until the early years of the present century that this information was co-ordinated into a scheme of zonation of general applicability. In a masterly thesis on the Cretaceous strata of the French Alps and adjoining regions, Jacob (1907) proposed the following classification:

ALBIAN		VIb	Subzone of *Mortoniceras inflatum* and *Turrilites bergeri*
		VIa	Subzone of *Mortoniceras hugardianum*
		V	Zone of *Hoplites dentatus*
		IV	Zone of *Hoplites (Leymeriella) tardefurcatus*
		III	Zone of *Douvilleiceras nodosocostatum* and *D. bigoureti*
APTIAN	Gargasian	IIb	Subzone of *Douvilleiceras subnodosocostatum* and *D. buxtorfi*
		IIa	Subzone of *Oppelia nisus* and *Hoplites furcatus*
	Bedoulian	I	Zone of *Parahoplites deshayesi* and *Ancyloceras matheronianum*

One of the notable features of this scheme was the dropping of *Douvilleiceras mammillatum* as a zone fossil, which had been used by Barrois (1874; 1875; 1878) and others in northern France, in favour of *Leymeriella tardefurcata*.

Kilian and Reboul's work (1915) on the Lower Aptian of the neighbourhood of Montélimar (Rhône Valley), based on a collection of fossils from the gigantic limestone quarries of l'Homme d'Armes, included a useful review of the Aptian ammonite succession in many parts of the world. They divided the Lower Aptian (Bedoulian) of this area into an upper and a lower division and showed that '*Parahoplites*' *deshayesi* occurred only in the upper division. They recognized a lower zone of '*P.*' *weissi* and '*Douvilleiceras*' *albrechti-austriae* (adopted from von Koenen 1902) and an upper zone of '*P.*' *deshayesi*.

Ganz (1912) gave a very full account of the Swiss Aptian and Albian and compared the succession with that of France and of England, using Jacob's zones.

In north Germany von Strombeck as early as 1856–61 had made out a faunal succession in the Aptian and Albian in which *Ammonites martini*, *A. tardefurcatus*, and *A. regularis* figured as characteristic fossils. A great step forwards was made in the investigation of the German sequence in the early part of this century by von Koenen (1902; 1907) and Stolley (1908*a*, *b*). Stolley, improving on an earlier scheme of von Koenen, put forward the following classification of the North German Aptian:

Zone of *Oppelia* (*Adolphia*) *trautscholdi* and *Parahoplites schmidti*
Zone of *Belemnites* aff. *ewaldi*, &c. (no ammonites)
Zone of *Hoplites deshayesi*
Zone of *Douvilleiceras albrechti-austriae* and *Parahoplites weissi*
Zone of *Hoplitides bodei*

Stolley combined belemnites and ammonites in his zonal tables and in the continuation of this work produced a similar scheme for the Lower Albian (styled 'Middle Gault'), naming species of *Hypacanthoplites*, *Nolaniceras* ('*Parahoplites*') and *Leymeriella* ('*Hoplites*') as the index ammonites, as follows:

Zone of *Hoplites regularis* and *Bel. strombecki* mut. *minor*
Zone of *Hoplites tardefurcatus*, *Parahoplites milletianus*, and *Bel.* n. sp. aff. *strombecki*
Zone of *Hoplites* aff. *tardefurcatus* } Beds with *Desmoceras keilhacki*
Zone of *Parahoplites jacobi* and *Bel. strombecki* } Beds with *Desmoceras keilhacki*
Zone of *Parahoplites nolani* and *Douv. cornuelianum*

Careful collecting from brickpits and other artificial openings around Hanover enabled Brinkmann (1937) to replace the top three zones by a more detailed scheme based on the occurrences of *Leymeriella*, as follows:

Zones	Subzones
Leymeriella regularis	*Hoplites* spp. *L. hitzeli*
Leymeriella tardefurcata	*L. tardefurcata tardefurcata* *L. tardefurcata anterior*
Leymeriella schrammeni	*L. schrammeni schrammeni* *L. schrammeni anterior*

Meanwhile, Spath (1923*b*) had proposed the following zonation of the Aptian and Lower Albian:

Lower Albian	Leymeriellan	*regularis* *milletianus* *schrammeni*
	Acanthoplitan	*jacobi* *nolani*
Upper Aptian	Parahoplitan (*subnodosocostatum* zone)	*aschiltaensis* *nutfieldensis*
	Tropaeuman (*martini* zone)	*tovilense* *bowerbanki* *hillsi*
Lower Aptian	Parahoplitoidan (*deshayesi* zone)	*consobrinoides* *hambrovi* *weissi* *bodei*
	Parancyloceratan (*recticostatus* zone)	*bidentatus* *rude* *sparsicosta*

At first sight this zonal scheme implies a great advance on the work of Jacob and Stolley. It must be pointed out, however, that it was not based on the principle of superposition as observed in the field, but on a perusal of the literature and examination of museum specimens. Although expressly put forward as a means of correlating British deposits, it was in fact not a zonal succession but a theoretical faunal sequence with 'index' fossils drawn from areas as far afield as north Germany, southern England, south-east France, and the Caucasus. It corresponds to nothing in Nature and its proposition seems to have been made according to the principles followed by Buckman, whose attempts at refined ammonite chronologies in the Jurassic have been the subject of so much adverse criticism. It is much to the credit of Spath, however, that he applied Buckman's methods with greater caution than did the master, and although the scheme reproduced above is unworkable in the field, contains much guesswork and some questionable correlation, the species are listed in the right order, so far as is known.

The principal innovation in this scheme was the insertion of the 'Parancyloceratan age' in the Lower Aptian. As originally published (Spath 1923*b*), no zonal index was chosen for the three subzones grouped in this 'age', but in 1924 he indicated that the zone of *Costidiscus recticostatus* lay above the upper limit of the Barremian and in a subsequent reproduction of this zonal scheme (Neaverson 1928) the word *recticostatus* was added as the zonal index. This was endorsed by Spath (1930*a*) on the grounds that varieties of *Costidiscus recticostatus* ranged up from the Barremian into the Lower Aptian, as also did *Macroscaphites*, another typically Barremian form. Spath showed that a Zone of *Douvilleiceras mammillatum* was separable above the beds with *Leymeriella tardefurcata* and *L. regularis* and in a later publication (Spath 1941, p. 668) he divided it into a Subzone of *Douvilleiceras monile* below and a Subzone of *D. inaequinodum* above. Contrary to the practice of the French, however, he placed this zone in the Middle Albian. Another change in the 1923 table was the replacement of *Hypacanthoplites milletianus* by *Leymeriella acuticostata* for the index fossil of the middle part of the *tardefurcata* Zone (Spath 1942, p. 673).

In 1947 an important review of the ammonite occurrences in the Albian of France and England was published by Breistroffer. This author's conclusions on zonation are summarized in the following table:

Lower Albian (Douvilleiceratian)	Zone of *Douvilleiceras monile* and *D. orbignyi* (Protohoplitan)	Horizon of *D. inaequinodum* (in England) Main level with *Protohoplites puzosianus*, *Sonneratia dutempleana*, *Cleoniceras cleon*
	Zone of *Leymeriella tardefurcata* and *Hypacanthoplites trivialis* (Leymeriellan)	Subzone of *L. canteriata* and *L.* (*Epileymeriella*) *hitzeli* Subzone of *L. tardefurcata* (and *L. acuticostata* in Hanover) Horizon of *L.* (*Proleymeriella*) *schrammeni* (in Hanover)
Upper Aptian (Clansayesian)	Zone of *Diadochoceras nodosocostatum* and *Acanthohoplites bigoureti* (Acanthohoplitan)	Subzone of *Hypacanthoplites jacobi* and *H. sarasini* Subzone of *H. nolani*, *Parahoplites grossouvrei*, and *Cheloniceras clansayense*

The *nodosocostatum* Zone, or 'Clansayes' horizon, which forms a kind of buffer-state between the classic Aptian and Albian, had been included in the Albian by Jacob, Stolley, and Spath. Breistroffer now showed that certain species of Albian affinities had been wrongly credited to this essentially Aptian horizon and that a more satisfactory starting-point for the Albian was at the base of the *tardefurcata* Zone. The 'Protohoplitan' (*mammillatum* Zone of other authors) was reinstated by Breistroffer in the Lower Albian, but *Douvilleiceras mammillatum* and *Leymeriella regularis* were both replaced by other index species.

Attempts to correlate the Aptian–Albian series of Europe with that of Texas (Trinity Group) by Scott (1940) and of south-east Arizona (Lowell Formation) by Stoyanow (1949) have led to new conceptions of zonation, supposedly of world-wide significance. Scott sought to interpose a Zone of *Sonneratia trinitensis* between the horizons of *Leymeriella regularis* and *Douvilleiceras mammillatum*. Among the changes in the 'standard' zonal scheme advocated by Stoyanow (1949, p. 38) was the shifting downwards of the *Sonneratia trinitensis* Zone to a position between that of *Leymeriella tardefurcata* and *Hypacanthoplites jacobi* and of the *Parahoplites* horizon (Spath's 'Parahoplitan age' or *subnodosocostatum* Zone) to the base of the Gargasian. He also proposed to draw the boundary of the Aptian and Albian stages between the horizons of *H. nolani* and *H. jacobi*.

The scheme of zonal classification here adopted is shown in Table 1. This is based on the order of succession seen in the Lower Greensand and can be demonstrated in the field. In this scheme the Aptian stage begins with the entry of the ammonite family Deshayesitidae. The zone of *Costidiscus recticostatus*, included by Spath in the Aptian, is found only in the Mediterranean region and has always been regarded as part of the Barremian. Coquand, who first proposed recognition of the Barremian Stage, regarded *C. recticostatus* as one of its characteristic fossils, of equal rank with *Macroscaphites ivani* (Coquand 1862). The various subzones included in the *recticostatus* Zone by Spath were named from north German occurrences. They were regarded by their originator, von Koenen, as Barremian, as also by Stolley (1908*a*) and Sinzow (1905). Their index fossils belong to the North Sea Province and have never been found in association with *Costidiscus*. Whatever relation these Mediterranean and Boreal elements have in time, there is no justification for removing them from the Barremian.

In the systematic part of this paper it is shown that the identification of *Deshayesites deshayesi* in this country was at fault and that the true *deshayesi* Zone is somewhat higher in the sequence than is indicated in Spath's table. Four well-marked zones may be recognized in the Lower Aptian based on occurrences of Deshayesitidae: (1) *fissicostatus* Zone, with *Prodeshayesites*, (2) *forbesi* Zone, with early *Deshayesites* of the *forbesi* type (= *D. deshayesi* Spath *non* d'Orbigny), (3) *deshayesi* Zone, with *Deshayesites* s.s., (4) *bowerbanki* Zone, with *Dufrenoyia*. *Tropaeum bowerbanki* is chosen as index-fossil for the highest zone of the Lower Aptian though *Dufrenoyia furcata* is equally characteristic. Unfortunately a '*furcatus* Zone', based on misidentification of d'Orbigny's *Ammonites dufrenoyi*, has been widely used in European literature for what is here called the *martinioides* Zone of the Upper Aptian. Of the various subzones of the '*deshayesi* Zone' employed by Spath, that of *D. weissi* cannot be recognized in the absence of the zonal ammonite, a German species. *Roloboceras hambrovi* has too long a range and the Russian *Deshayesites consobrinoides* is less suitable for British strata than *Cheloniceras parinodum* sp. nov.

To fix a boundary in line with the base of the Upper Aptian (Gargasian) of south-east France, I have taken the appearance of *Epicheloniceras* as diagnostic. It is regretted that the '*martini* Zone', so familiar to British geologists as the name for the lower part of the Upper Aptian, must be abandoned, for reasons given in the systematic chapter. The Russians (e.g. Sazonova 1958) have used *Ch.* (*Epicheloniceras*) *tschernyschewi*, *Ch.* (*E.*) *subnodosocostatum*, and *Gargasiceras gargasense* as guide fossils for this part of the succession. The first is exceedingly rare in Britain, the third is unknown in this country, and the second has been used incorrectly for what is now called the *nutfieldensis* Zone. *Cheloniceras* (*E.*) *martinioides* sp. nov. is the best Lower Greensand substitute for '*A. martini*', for which indeed it has generally passed. *Tropaeum hillsi* and *T. bowerbanki* are Lower Aptian species that were misplaced in the '*martini* Zone' in Spath's table (Casey 1960*a*, p. 25 footnote) and the same author's use of *Ammonitoceras*

TABLE 1. *Zonal classification and correlation of the Lower Greensand.*

	ZONES	SUBZONES	ISLE OF WIGHT	EAST KENT	WEST KENT	SURREY	SUSSEX	WESTERN OUTLIERS	NORTHERN BASIN
LOWER ALBIAN	DOUVILLEICERAS MAMMILLATUM	PROTOHOPLITES (HEMISONNERATIA) PUZOSIANUS	CARSTONE	FOLKESTONE BEDS: SULPHUR BAND; MAIN MAMMILLATUM BED	NODULE BEDS AT JUNCTION WITH GAULT	NODULE BEDS AT JUNCTION WITH GAULT	FOLKESTONE BEDS: NODULE BEDS AT JUNCTION WITH GAULT	GLAUCONITIC SANDS AT BASE OF GAULT	
		OTOHOPLITES RAULINIANUS							
		CLEONICERAS FLORIDUM							
		SONNERATIA KITCHINI		S. KITCHINI BED	NON-SEQUENCE				LEIGHTON BUZZARD NODULE BANDS I–III
	LEYMERIELLA TARDEFURCATA	LEYMERIELLA REGULARIS	NON-SEQUENCE	MAIN MASS OF BED 3			HOPTON WOOD CLAY		SHENLEY LIMESTONE
		HYPACANTHOPLITES MILLETIOIDES	SANDROCK	BED 2	FOLKESTONE BEDS	FOLKESTONE BEDS: UPPER PEBBLY SANDS		? RED SANDS OF UFFINGTON ETC.	WOBURN SANDS (PARS); CARSTONE (LIMITS UNKNOWN)
		FARNHAMIA FARNHAMENSIS		NON-SEQUENCE		FARNHAMIA BAND ?= CLAY-SILT BAND			
UPPER APTIAN	HYPACANTHOPLITES JACOBI	HYPACANTHOPLITES ANGLICUS		BED I		SILVER SANDS			
		HYPACANTHOPLITES RUBRICOSUS							
		NOLANICERAS NOLANI	FERRUGINOUS SANDS: ? CLAY BAND OF GROUP XV	SANDGATE BEDS: MAIN MASS	SANDGATE BEDS	BASAL PEBBLY SANDS	? MAREHILL CLAY		
	PARAHOPLITES NUTFIELDENSIS	PARAHOPLITES CUNNINGTONI	GROUP XIV			SANDGATE BEDS: PUTTENHAM BEDS	IRON SANDS	IRON SANDS OF SEEND	UPWARE SUTTERBY MARL
		TROPAEUM SUBARCTICUM	GROUP XIII			BARGATE & FULLERS EARTH BEDS	BARGATE BEDS	FARINGDON SPONGE GRAVELS	
	CHELONICERAS MARTINIOIDES	CHELONICERAS (EPICHELONICERAS) BUXTORFI	? GROUPS XI & XII	BASAL NODULE BED	HYTHE BEDS: BOUGHTON GROUP	HYTHE BEDS: TOP CHERTS OF BLACKDOWN AND GODSTONE; NON SEQUENCE	HYTHE BEDS		
		CHELONICERAS (EPICHELONICERAS) GRACILE	GROUPS IX & X						
		CHELONICERAS (EPICHELONICERAS) DEBILE	GROUP VIII						
LOWER APTIAN	TROPAEUM BOWERBANKI	CHELONICERAS (CHELONICERAS) MEYENDORFFI	GROUP VII	HYTHE BEDS	BEDS BELOW COALMAN LANE	TOP HYTHE PEBBLE BED; MID HYTHE SANDS			HUNSTANTON, SUTTERBY, ?UPWARE (DERIVED)
		DUFRENOYIA TRANSITORIA	GROUP VI						
	DESHAYESITES DESHAYESI	DESHAYESITES GRANDIS	GROUP V			LOWER HYTHE STONE			
		CHELONICERAS (CHELONICERAS) PARINODUM	GROUP IV						SUTTERBY, UPWARE (DERIVED)
	DESHAYESITES FORBESI	DESHAYESITES CALLIDISCUS	ATHERFIELD CLAY SERIES: UPPER LOBSTER BED & CRACKERS	ATHERFIELD CLAY	ATHERFIELD CLAY		ATHERFIELD CLAY		?UPWARE (DERIVED)
		DESHAYESITES KILIANI	LOWER LOBSTER BED						
		DESHAYESITES FITTONI	ATHERFIELD CLAY S.S.						
	PRODESHAYESITES FISSICOSTATUS	PRODESHAYESITES OBSOLETUS	PERNA BEDS		PERNA BED	PERNA BED			
		PRODESHAYESITES BODEI							HUNSTANTON, UPWARE, POTTON, SUTTERBY (DERIVED)

tovilense as an index-fossil for part of this zone can scarcely be approved, this ammonite being known by a single example undocumented as to horizon. The three divisions of the *martinioides* Zone here recognized are characterized by species of *Epicheloniceras*, the topmost being *Ch.* (*E.*) *buxtorfi*, adopted as a guide-fossil from Jacob.

Arkell's (1947*a*) proposal to drop *Ch.* (*E.*) *subnodosocostatum* in favour of *Parahoplites nutfieldensis* for the zone fossil of the Upper Gargasian is here endorsed. Working at great distance from the European museums and apparently handicapped by lack of literature, Stoyanow (1949) reached the conclusion that European authors had misapprehended the nature and stratigraphical position of the genus *Parahoplites* in its restricted sense. He failed to see that far from being unique in North America his *Kasanskyella* and '*Sinzowiella*' (both analogous to *Parahoplites*) were congeneric, if not conspecific, with Scott's species of '*Sonneratia*' from the *trinitensis* Zone of Texas (compare Stoyanow, pl. 17, figs. 5, 6, and Scott 1940, pl. 66, fig. 2, and pl. 67, fig. 7) and that in fact the *trinitensis* Zone and his own Zone of *Parahoplites melchioris* are one and the same thing. Russian literature has always been consistent in placing *P. melchioris* and its allies above, not below, *Dufrenoyia* (Sinzow 1909; Natsky 1918; Sazonova 1958), which agrees with what is seen in Western Europe and in Texas. In Arizona beds with *Kasanskyella* are followed directly by strata with *Diadochoceras* or a close ally (= *Paracanthohoplites*); the '*Dufrenoyia*' from the overlying Joserita and Cholla members are acanthohoplitids comparable with those described by Benavides-Cáceres (1956) from northern Peru as *Parahoplites inta* and *P. quilla* and placed at the base of the Albian ('Zone of *Parahoplites nicholsoni*'). It is clear, therefore, that the succession in Arizona is not very different from that of Eurasia, though having a greatly expanded development of the 'Clansayes' horizon. It is true that one of Sinzow's species of *Parahoplites*, or a form comparable therewith (*P.* cf. *multicostatus*), has been figured and described from La Peña formation of Mexico (Humphrey 1949, pl. 12, p. 138), of Lower Gargasian age, but the ammonite in question is a *Colombiceras* of the group of *C. alexandrinum* (d'Orbigny) and quite properly associated with *Dufrenoyia*.

I have followed Breistroffer (1947) in extending the Aptian to take in the 'Clansayes' horizon, and in accordance with his views (though not his nomenclature) the Lower Albian is understood to comprise the two zones of *Leymeriella tardefurcata* and *Douvilleiceras mammillatum*. The *tardefurcata* Zone seems to mark a new beginning for the ammonites, in Europe at least (Casey 1957), and this is the level best fitted to start the Albian. I have already pointed out (Casey 1950; 1957) that there is no need to follow Breistroffer in replacing *Leymeriella regularis* as the guide-fossil for the topmost part of the *tardefurcata* Zone and his objections to the name *Douvilleiceras mammillatum* have also been removed (Casey 1954*b*). It should be noted, however, that the *mammillatum* Zone of my table corresponds only to the lower half of Spath's *mammillatum* Zone, i.e. his *monile* Subzone. Above this level there is a great change in ammonite fauna; *Otohoplites*, *Protohoplites*, *Hemisonneratia*, *Sonneratia*, *Pseudosonneratia*, and *Tetrahoplites* disappear and are replaced by *Hoplites*, entry of which, in the Zone of *Hoplites dentatus*, marks the commencement of the Middle Albian. It is now proposed to extend the *dentatus* Zone downwards to include a Subzone of *Hoplites* (*Isohoplites*) *eodentatus* sp. nov., corresponding more or less to Spath's Subzone of *Douvilleiceras inaequinodum*. The former is characteristic and widespread, being known from many localities in south-east England and from northern France (Destombes 1958, p. 309), and is preferable to *D. inaequinodum*, which is much too rare and has too long a range to be a suitable horizon-marker for the base of the Middle Albian and the base of the English Gault.

DEPOSITIONAL HISTORY OF THE LOWER GREENSAND

Lower Greensand sediments were accumulated in two main basins, separated by the relics of an Armorican mountain range that crossed the London area and extended westwards over the south-east midlands of England. This area of Palaeozoic rocks, now deeply buried, is one of the fundamental structural boundaries of Mesozoic Europe and includes the so-called London Ridge or Platform, whose eastern prolongation breaks surface in the Ardennes of northern France and Belgium. The two Lower Greensand basins thus marked off had different geological settings. In the south the sea had long retreated and the old Jurassic trough of south-east England had become the site of fresh- and brackish-water lagoons and delta swamps in which were deposited the Purbeck and Wealden Beds. In the Northern Basin, on the other hand, the Cretaceous sea never completely withdrew. At the southern end of the basin, in Cambridgeshire and Bedfordshire, the Jurassic sea-floor was brought up within range of erosion, but northwards, in Norfolk and Lincolnshire, the sea maintained a footing, albeit precarious, throughout the Neocomian.

In addition to this main structural feature which divided the Lower Greensand area of deposition into two, there are other, minor ridges or axes of uplift that served to demarcate sedimentary provinces within the two basins (text-fig. 1). From a study of deep-boring records, Kent (1949) has inferred that the Sussex coast overlies a structural nose that may be a continuation of the Paris–Plage ridge. King (1954) suggested that this feature influenced Mesozoic deposition on an east-to-west axis stretching across the Channel into southern England in the Beachy Head area. The attenuation of the Lower Greensand in the Portsdown boring (Taitt and Kent 1958) is explicable on the assumption that the westward prolongation of this ridge affected sedimentation in Aptian times. It is here suggested that this ridge functioned as a boundary between the Vectian and Wealden Provinces of the Southern Basin.

The Northern Basin is readily divisible into a Cambridge–Bedford Province and a Lincolnshire–Norfolk Province, such division being apparent from the map in the manner in which the outcrop is lost under the Fens north of Ely. Borings in this area show that at depth the Lower Greensand has dwindled almost to nothing. At Upware, near Ely, the Lower Greensand is banked against a ridge of Corallian rocks, but it is unknown whether the dominant tectonic lines in Lower Greensand times ran east to west, as I have tentatively indicated them in text-fig. 1. At the extreme north the Lower Greensand outcrop terminates in the region of the Market Weighton upwarp. Beyond this is preserved a portion of another Lower Cretaceous basin, that of the Speeton Clay, outside the scope of the present work.

In the Southern Basin Lower Greensand deposition commenced with the Atherfield Clay. The idea that the Atherfield Clay of the Isle of Wight is older than that of the mainland (Spath 1930*a*) and that the incoming Lower Greensand sea spread from south to north is not supported by the present study of the ammonites. The same ammonite fauna (*Prodeshayesites obsoletus* and allies) is found in the Perna Beds, at the base of the Atherfield Clay, in the Isle of Wight and in Surrey. On the other hand, in East Kent there is no Perna Bed at the base of the Lower Greensand; there the succession commences high in the *forbesi* Zone (*callidiscus* Subzone). Commencement of Lower Greensand deposition in East Kent coincided with uplift in the Vectian Province, leading to formation of the Crackers in the Isle of Wight and the Punfield Marine Band in Dorset. A similarity between the fauna of the Punfield Marine Band (with the gastropod *Cassiope*) and that of the Aptian of eastern Spain, first noticed by Judd (1871), has been frequently claimed as evidence of a sea connexion between the two regions. It is tempting to take this as supporting the notion of a westerly source for the invading Lower Greensand sea. Unhappily, as mentioned elsewhere, the fauna of the Punfield Marine Band owes its distinctiveness to difference of facies: it is a marine-brackish deposit, and the reason its fauna is not found in the Aptian of France is not because sea-routes did not exist, but because conditions of normal salinity prevented the fauna using them at that time. Too much has been made of the Spanish affinities of the Punfield fauna. *Cassiope lujani*, *C. helvetica*, and an assemblage of opisthobranchs comparable with that of Punfield is found in the Upper Barremian of the Paris Basin (Gillet 1921).

Following the deposition of the Atherfield Clay Series and coinciding with the arrival of the new fauna of the *deshayesi* Zone, there was an influx of sandy sediment leading to the formation of the Hythe Beds. In the Eastern Weald the sands are strongly calcareous, possibly owing to erosion of limestones on the London Platform (Kirkaldy 1939, p. 399). This change in fauna and sediment was probably accompanied by shrinkage of the area of deposition, for in East Kent the Hythe Beds have a more restricted distribution than the underlying Atherfield Clay.

The Upper Aptian was ushered in by movements more extensive than any that had previously affected deposition of the Lower Greensand. In the Isle of Wight, in West Kent, and in the Western Weald around Haslemere, sedimentation continued with only minor interruptions, but elsewhere in southern England there was a period of retrenchment and of destruction of pre-existing deposits. In the Northern Basin the *bowerbanki*, *deshayesi*, *forbesi*, and *fissicostatus* Zones were broken up and their rolled and phosphatized fossils now form a basal conglomerate to strata of *nutfieldensis* or later date. From published evidence (Dutertre 1923, 1925; Corroy 1925) we may infer a synchronous phase of movement in the Boulonnais and the Paris Basin. In the Kent coalfield the *nutfieldensis* Zone rests unconformably on the *forbesi* Zone (Atherfield Clay) or on remnants of the *bowerbanki* Zone (Hythe Beds), as it does in the Godalming area of Surrey. The passage from the marginal area of destruction to that of normal deposition takes place in the few miles of outcrop centred on Ashford, Kent, where the *martinioides* Zone is represented by a band of phosphatic nodules and remanié fossils at the base of the Sandgate Beds. In the Weald the *martinioides* Zone reaches its maximum thickness in the neighbourhood of Offham, between Maidstone and Sevenoaks, and thins out when traced along the outcrop south-west and south-east from that area, disappearing at Reigate and south-east of Little Chart respectively. A line connecting these two points coincides almost exactly with the railway-line from Ashford to Redhill, trending a few degrees north of west.

A renewed transgression commencing with the Sandgate Beds (*nutfieldensis* Zone) carried the sea far into the West Country, passing over ground faulted probably at the time of the *martinioides* retrenchment. The waters of the Southern and Northern Basins now joined and for the first time there was interchange of Lower Greensand marine fauna.

The Folkestone Beds saw another episode of shallowing of the basin and perhaps of withdrawal from the newly won ground in the west. Vast quantities of quartz sand poured into the basin and were swept around by strong currents before coming to rest. Here and there the bedding structures and well polished sand-grains suggest that the sands are in part re-sorted coastal dunes or near-surface sand-bars. Possibly the Western Outliers, e.g. Seend and Calne, were oxidized at this time.

The change from Aptian to Albian time occurred while the Folkestone Beds were being formed and at the margins of the basin in East Kent and East Sussex it was marked by a break in the flow of sediment and winnowing of the sea-bed. In Surrey, where the beds are thickest, the only physical expression of the stage boundary was an interval of slow deposition and slack water. Deposition of the middle part of the *tardefurcata* Zone (*milletioides* Subzone) was followed by a period of instability during which the sediments were folded gently along east-to-west axes and eroded. A long phase of inhibited deposition then ensued until the end of the Lower Greensand, this phase being characterized by the formation of phosphatic nodule beds (often with radioactive enrichment) of *regularis* and *mammillatum* age. Downwarped areas provided a maze of local troughs or 'dimples' in which sediments of *regularis* age—sand, clay, or limestone—were laid down; elsewhere, on the crests and flanks of the folds, erosion or oxidation proceeded and sedimentation was not established until some time in the *mammillatum* Zone. Strata above this mid-*tardefurcata* break thus show great lateral variation, the basement-beds varying in age and lithology from place to place depending on the site of the trough and the position they occupy in it. This is the most widespread gap in the Lower Greensand; everywhere below the *regularis* Subzone in England there is a sharp junction, either a plane of erosion, a bed of phosphatic nodules, or a sudden change in lithology. In the Isle of Wight the critical level is at the junction of the Sandrock and the Carstone; around Leighton Buzzard it is the iron-cemented top of the 'Silver Sands'. In East Kent the outcrop gives a natural section through a *regularis–mammillatum* trough scooped out in *milletioides* and *jacobi* sediments. Proceeding north-eastwards from East Cliff, Folkestone, where the *regularis* sandstones are preserved in the centre of the trough, we may observe the various subzones wedging out, until at Quarrington Wood, about 10 miles from East Cliff, the topmost part of the *mammillatum* Zone passes into an ironstone at the rim of the trough. We are at present unable to define the extent of this unconformity or disconformity in terms of ammonite chronology. The only region where the *tardefurcata* Zone succession is known in detail is in north Germany, and there the ammonites are of a different facies. Possibly the German Subzone of *Leymeriella acuticostata*, which lies next below that of *L. regularis*, bridges this gap in the Lower Greensand. The fact that neither *L. acuticostata* nor any other ammonites that could fill this gap are known in France may indicate that the effects of mid-*tardefurcata* movement were felt over a much wider area than the British Province.

STRATIGRAPHICAL ACCOUNT

Lower Greensand outcrops are shown on the map in text-fig. 1. These outcrops are discontinuous and extend from Folkestone, Kent, westwards to Dilton, Wiltshire, and from the southern tip of the Isle of Wight northwards to the neighbourhood of Market Weighton, Yorkshire. This great expanse of Lower Greensand country may be divided into the following geographical provinces, each a natural sedimentary trough:

Southern Basin	*Northern Basin*
Vectian Province	Cambridge–Bedford Province
Wealden Province	Lincolnshire–Norfolk Province

SOUTHERN BASIN

Vectian Province

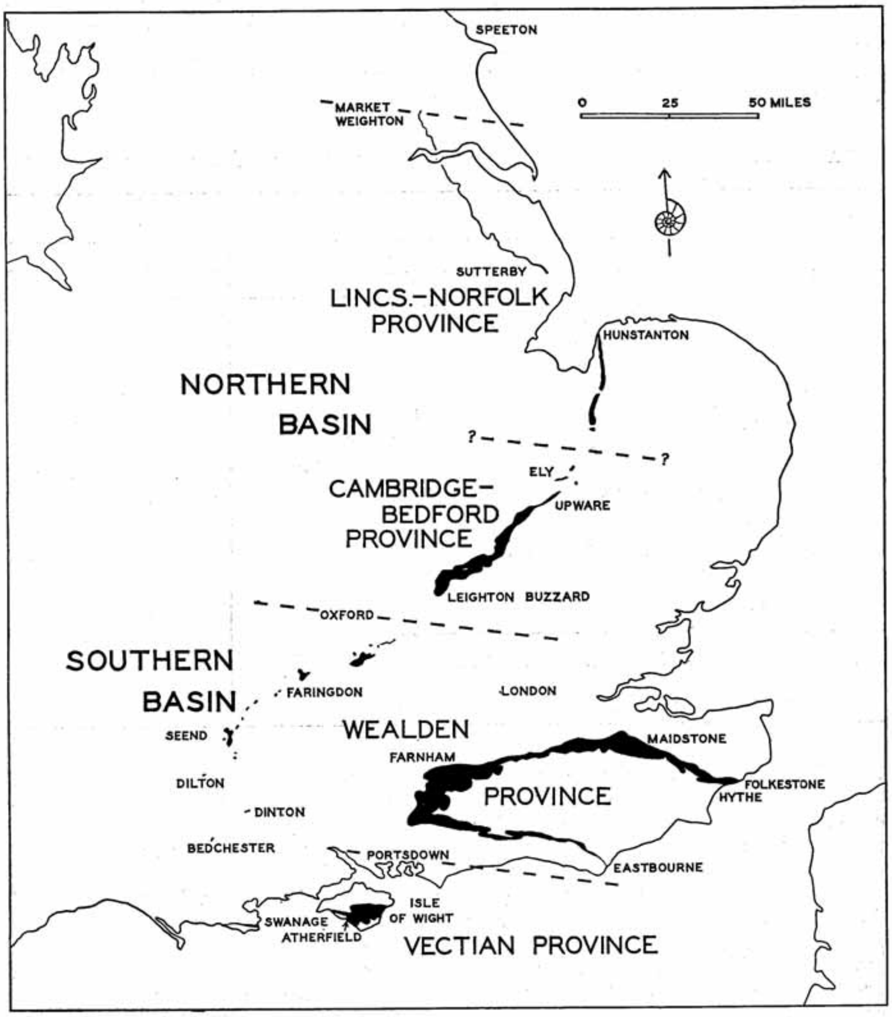
The Vectian Province comprises the Isle of Wight and a small part of the Dorset mainland where a strip of Lower Greensand extends westwards from Swanage to Lulworth Cove.

Isle of Wight

The greater part of the southern or Cretaceous area of the Island is occupied by the Lower Greensand, but the country is largely under cultivation and inland exposures are few and insignificant. The formation is best seen in the sea-cliffs at Chale Bay and Compton Bay, on the south-west side of the Island, and at Shanklin and Redcliff, on the south-east side. At Redcliff the Lower Greensand is about 600 feet thick; at Chale Bay it has increased to over 800 feet, but at Compton Bay, about 16 miles west of Redcliff, the thickness is reduced to 400 feet. At Punfield, near Swanage, on the Dorset coast, 20 miles west of Compton Bay, it is no more than 198 feet. This means that the direction in which the formation as a whole thickens most rapidly lies a little east of south. An exception to this generalization is the Carstone, at the top of the formation, which is thickest at Redcliff.

The Lower Greensand of the Isle of Wight was carefully examined by Fitton in the years 1824–47 and the results of his work appeared in a number of papers, chiefly in that published in 1847. This paper gave a bed-by-bed description of the Atherfield (Chale Bay) section and correlated it with strata in other parts of the Island, on the mainland, and in France. Fitton employed a professional collector, Charles Wheeler, to help him collect fossils and most of these were passed to J. Morris for naming, a few being done by T. Lonsdale and J. de C. Sowerby. Fitton divided the Lower Greensand of the Isle of Wight into six major units (lettered A–F), sixteen 'Groups' (given names and roman numerals), and fifty-five beds. Ibbetson and Forbes (1845) had measured the section independently, but later authors were content to paraphrase Fitton's account and to add little or nothing new (e.g. Bristow 1862, 1889; Wright 1864; Norman 1887; Leriche 1905; Osborne White 1921; Chatwin 1935; Kirkaldy 1939). Fitton's scheme, emended by the Geological Survey (Strahan *in* Bristow 1889) and with further small changes now introduced, is shown in Table 2 on p. 504.

In place of Fitton's six major units the Geological Survey found it better to adopt a fourfold division, as follows: (1) Atherfield Clay, (2) Ferruginous Sands, (3) Sandrock, and (4) Carstone. The Atherfield Clay was extended to take in the Perna Beds below and the basal portion of the Crackers Group (Lower Lobster Bed) above. Similarly, the Ferruginous Sands, though roughly equal to Fitton's division D (Groups IV to XIV), embraced also most of Group III (Crackers) and a thick bed of sandy clay at the base of Group XV. Most of Fitton's Group XV and a portion of the overlying Group XVI were brought together by the Survey under the name Sandrock, the term Carstone being reserved for the rest of Group XVI. As redefined by the Survey the Atherfield Clay was considered equivalent to the beds of the same name on the mainland; the Ferruginous Sands were correlated with the Hythe and Sandgate Beds of the mainland; and the combined Sandrock and Carstone were taken to represent the Folkestone Beds.



TEXT-FIG. 1. Distribution of the Lower Greensand. Outcrops are shown solid black, provincial boundaries by broken lines.

The only change in the Survey's scheme now advocated is in the boundary of the Atherfield Clay and the Ferruginous Sands. Fossils and lithology show that Fitton was right to draw the line between his divisions C and D at the base of the Lower Gryphaea Beds (Group IV). The

Crackers rocks, included in the Ferruginous Sands by the Survey, are merely a local sandy phase in an essentially argillaceous succession. Not only are the beds next above them (Upper Lobster Beds) Atherfield Clay in the lithological sense, but it now appears that they are the correlatives of much of the Atherfield Clay of the mainland. It is proposed, therefore, to take the bottom of Group IV as the base of the Ferruginous Sands and to designate the beds below, i.e. the Perna Beds, Atherfield Clay s.s., and the Crackers Group (with Lower Lobster Bed at base and Upper Lobster Beds at top), the Atherfield Clay Series.

TABLE 2. *Divisions and subdivisions of the Lower Greensand of the Isle of Wight*

<table>
<tr><th colspan="2">Fitton 1847</th><th>Geological Survey 1889</th><th>Present author</th></tr>
<tr><td>XVI. Various Sands and Clays</td><td>F</td><td>Carstone</td><td>Carstone</td></tr>
<tr><td>XV. Upper Clays and Sandrock</td><td>E</td><td>Sandrock</td><td>Sandrock</td></tr>
<tr><td>XIV. Ferruginous Bands of Blackgang Chine
XIII. Sands of Walpen Undercliff
XII. Foliated Clay and Sand
XI. Cliff-end Sands
X. Upper Gryphaea Beds
IX. Walpen and Ladder Sands
VIII. Upper Crioceras Beds
VII. Walpen Clay and Sand
VI. Lower Crioceras Bed
V. Scaphites Beds
IV. Lower Gryphaea Beds</td><td>D</td><td rowspan="2">Ferruginous Sands</td><td>Ferruginous Sands</td></tr>
<tr><td>III. { Upper Lobster Beds
Crackers
Lower Lobster Bed</td><td>C</td><td rowspan="3">Atherfield Clay Series</td></tr>
<tr><td>II. Atherfield Clay</td><td>B</td><td rowspan="2">Atherfield Clay</td></tr>
<tr><td>I. Perna Beds</td><td>A</td></tr>
</table>

Atherfield (*Chale Bay*). By far the best section, and the most productive of fossils, is that of Chale Bay. Here a shallow embayment of the coast extends from Atherfield Point south-eastwards to Rocken End, a distance of 3½ miles, in which the gentle dip of the strata brings the whole thickness of the Lower Greensand into view. To conform with earlier literature the Chale Bay exposure will be referred to simply as Atherfield.

The cliffs are high and precipitous, lapped by the waves at high water. Between Atherfield Point and Rocken End ascent from the shore can be made only at one point, Whale Chine, about a mile from Atherfield Point; it is essential, therefore, to examine the section on a receding tide. Cliff falls are frequent and much of the section may be obscured by downwash, and from time to time sand and shingle smother the foreshore exposures, the best places for collecting fossils. Fossils occur mostly in hard concretions and serious work requires a sledge-hammer.

Text-fig. 2 illustrates the zonation of the Atherfield section and its correlation with the Lower Greensand of the Kent coast. The full thickness of the beds at Atherfield has been variously estimated at 808 feet (Fitton 1847*a*), 833 feet (Ibbetson and Forbes 1845), and 752 feet 11 inches (Simms 1845). Experience has taught me to take Fitton as the guide.

Atherfield Clay Series. The basal few feet of the Lower Greensand at Atherfield form a well-defined division, distinguished by Fitton as the Perna Beds in consequence of their containing large numbers of the lamellibranch *Mulletia mulleti*, formerly called *Perna mulleti*. This division appears at the top of the cliff about 300 yards south of Shepherd's Chine and descends to the beach 150 yards east of Atherfield Point, where it forms a ledge running out to sea. Frequently this part of the section is concealed by slips and mudflows from the Atherfield Clay, though fossil-collecting can always be done from the boulders on the beach. The fauna is one of the richest in the Lower Greensand, the sandstone at the top being full of large lamellibranchs such as *Mulletia mulleti*, *Isognomon ricordeanus*, *Gervillella sublanceolata*, *Gervillaria alaeformis*, *Exogyra latissima*, *Prohinnites favrinus*, *Sphaera corrugata*, *Protocardia sphaeroidea*, *Astarte obovata*, *Venilicardia protensa*, *Noramya forbesi*, and *Yaadia nodosa*, together with the nautiloid *Cymatoceras radiatum*, the gastropods *Fossarus munitus* and *Globularia sublaevigata*, the brachiopods *Sulcirhynchia hythensis* and *Sellithyris sella*, knobs of coral (*Holocystis elegans*), and many other fossils. The hydrozoan *Lonsda contortuplicata*, once thought to be a sponge, is found here. Indigenous ammonites are very rare. This is the only horizon in the Lower Greensand where corals are abundant and the occurrence may be linked with the great phase of reef-building that characterized the Barremian-Aptian deposits of the Tethyan belt from southern Europe to Venezuela and Mexico.

Section of the Perna Beds at Atherfield Point

	ft.	*in.*
3. Grey-green calcareous sandstone, ironstained in patches. Very fossiliferous .	2	6
2. Dark greenish-blue sandy clay with pyrites. Many fossils, including *Panopea* standing upright	2	6
1. Line of grit, small pebbles, fish debris, and small black nodules, some rolled bits of Kimmeridgian *Pavlovia*		1

Sharp junction with Wealden Shales

Teeth of *Hybodus*, *Acrodus*, and the primitive myliobatid *Hylaeobatis problematica* occur not only in the basal grit but also (more rarely) in beds 2 and 3; most are derivatives from the Wealden, though some may belong to the native fish fauna, as apparently do the associated teeth of *Scapanorhynchus*. Fitton called the basal grit and the clay above the 'Lower Perna Bed' and said that it contained the ammonite *A. furcatus*. This is an impossible horizon for the species, a form of *Dufrenoyia*, and I feel sure that what Fitton found was a derived Jurassic *Pavlovia*. No ammonites have been obtained from bed 2, though at Sandown this bed has yielded *Prodeshayesites obsoletus* gen. et sp. nov. This species occurs at both localities in bed 3, the 'Upper Perna Bed' of Fitton, accompanied by specifically indeterminate *Deshayesites*, and is the species recorded from here by him (1847, p. 296) and other authors as *A. leopoldinus*. The identity of the other ammonites listed by Fitton from this bed, namely *A. deshayesi*, *A. furcatus*, and *A. inflatus*, can only be surmised. *Ammonites inflatus* was recorded by him also from the Atherfield Clay and is a puzzling addition to the faunal list, this species being an Upper Albian *Mortoniceras*. In the Geological Survey Museum there is a specimen of '*A. inflatus*' from 'Atherfield' which was originally presented by Fitton to the Geological Society and which was cited by Forbes (1845, p. 355) (GSM Geol. Soc. Coll. 2296). It is a specimen of *Mortoniceras fissicostatum* (Spath), of Upper Albian age, and is in a malmstone quite foreign to the Lower Greensand, though typical of Potterne, Wiltshire, one of the principal sources of the *Mortoniceras* fauna in this country. The citation of *Ancyloceras matheronianum* from the Perna Beds of Atherfield is incorrect (Casey 1960*a*, p. 22).

Spath's supposition that the Perna Beds are of *bodei* age (Spath 1923*b*) was a close approximation to the truth. In my zonal scheme the Perna Beds represent the upper half of the *fissicostatum* Zone (*obsoletus* Subzone). The gritty seam at the base may mark an interval of time during which the lower half of the zone (*bodei* Subzone) was laid down elsewhere.

The Perna Beds are followed upwards by 60 or 70 feet of brown-weathering, bluish-grey, silty clay, to which Fitton originally applied the name Atherfield Clay. The clay is devoid of lamination and abounds in flattened nodules of red or white clay-ironstone, red nodules predominating in the lower part. In places the clay has the qualities of fuller's earth. Wasting of the Atherfield Clay is rapid and unceasing and a clear, measurable section is rarely seen owing to cliff-founders and sludge-streams. Most of the ammonites here recorded from this part of the succession were obtained in the few months following the great gale of October 1954, when the shore was stripped down to bedrock. The fauna is dominantly molluscan, the lamellibranchs *Nuculana scapha*, *Aptolinter aptiensis*, *Pseudoptera subdepressa*, *Pinna robinaldina*, *Panopea gurgitis*, *Resatrix dolabra*, *Parmicorbula striatula*, and the gastropod *Anchura* (*Perissoptera*) *robinaldina* being locally common. Ammonites are less frequent and occur either as crushed impressions in the clay or as clay-ironstone internal moulds, generally of the body-chamber only. They include a few fragments of *Prodeshayesites* from the bottom 15 feet, a single *Roloboceras* from 20 feet above the Perna Beds, and various *Deshayesites*. Of these, the zone fossil *D. forbesi* sp. nov. ranges almost throughout, but the chief form is the subzonal index, *D. fittoni* sp. nov., which has been collected in numbers between 10 and 40 feet above the Perna Beds. Spath's '*Procheloniceras* cf. *pachystephanus* (Uhlig)' and '*Procheloniceras* ? sp. indet.', said to be the only two ammonites known from the Atherfield Clay (Spath 1930*a*, pp. 422, 443), are distorted pieces of large *Deshayesites*. Spath (1923*b*) correlated the Atherfield Clay with the *weissi* Zone of the German Aptian, but *Deshayesites weissi* has not been found here, as supposed by Neaverson (1928). Not infrequently bunches of branched tubes composed of tiny ovoid pellets weather out from the clay; similar structures in the London Clay are known as '*Granularia*' and are thought to be the faeces of holothurians or annelids. Washed samples of the clay give a large sand residue almost barren of microzoa.

The succeeding Lower Lobster Bed is an impure fuller's earth, brownish or bluish-grey, with white clay-ironstone nodules like those in the beds below. Near the top it has small sandy concretions similar to those which occur on a large scale in the Crackers above. It crops out on the shore north-west of the promontory of Crackers rocks but is seldom free of shingle. In the cliff it is generally concealed by slipped material, though fallen blocks are at times available. Fitton gives the thickness of the bed as 25 feet 6 inches; Ibbetson and Forbes as 29 feet. Fossils are much more abundant and better preserved than in the Atherfield Clay. Many of the molluscs have the test, others are internal moulds in calcite, clay-ironstone, or iron-pyrites. Commonly the larger fossils are coated with adherent oysters and some appear water-worn. In the words of Fitton: 'the fossils of this bed occur in thin clots or clusters, often without any covering or crust, as if they had been just left upon a sand-bank at the bottom of the sea'. The bed takes its name from the common occurrence of the prawn *Meyeria magna* (= *M. vectensis*). A small crab, *Mithracites vectensis*, also occurs, but true lobsters, such as

EXPLANATION OF PLATE 77

Fig. 1. Whale Chine, Isle of Wight, looking north-west to Atherfield Point. The Lower Crioceras Bed crops out by the posts at the mouth of the Chine. Concretions of the Upper Crioceras Beds may be seen in ranges high in the cliff and as boulders on the beach.

Fig. 2. The Crackers, Atherfield. The upper line of concretions is seen *in situ* just below the middle of the photograph, followed upwards by Upper Lobster Beds and, high in the cliff, Ferruginous Sands.

Fig. 3. Ladder and Walpen Chines, Isle of Wight, looking south-east to St. Catherine's Point. Cliffs of Ferruginous Sands. Group VII in the foreground.

the nephropsid *Homarus longimanus* and the palinurid *Linuparus carteri*, are much less frequent. The lamellibranch and gastropod fauna is more or less the same as that of the Crackers. The ammonites include: *Deshayesites forbesi* sp. nov., *D. kiliani*, *D. topleyi*, *D. punfieldensis*, *D. spp. nov.*, *Roloboceras hambrovi*, *R. perli*, *R. horridum*, *R. spp. nov.*, *Megatyloceras sp. nov.* The subzonal index is *Deshayesites kiliani; Roloboceras hambrovi* is equally characteristic but ranges into higher beds. It is here that *Roloboceras* reaches its acme, and its association with the allied genus *Megatyloceras* is especially interesting. *Megatyloceras* has not been found in Britain before and the only other known authentic occurrences of the genus are in Georgia, U.S.S.R., and Yonne, France, both poorly localized in the succession. This is the horizon of *Heminautilus saxbyi*, a discoidal nautiloid; also of *Deshayesites punfieldensis*, wrongly attributed to the Punfield Marine Band.

Next above the Lower Lobster Bed is the Crackers, 20 feet of firm grey and brown clayey sand with two lines of sandy calcareous concretions, exceptionally rich in fossil mollusca. These concretions are large and rounded but of an irregular size and shape like boulders, those in the lower tier reaching 6 or 7 feet in length and 2 feet in thickness. Some are cemented clusters of a single species of shell, usually the lamellibranchs *Gervillella sublanceolata* or *Yaadia nodosa*, or the ammonite *Deshayesites forbesi*. Smaller nodules, with stony crust only 2 or 3 inches thick, generally have a softer core from which fossils may be extracted in perfect condition, horn-coloured and translucent. On account of their relative hardness, the Crackers make a prominence in the cliff-line about 600 yards east of Atherfield Coastguard Station. Here the sea hollows out the sand below the concretions and the rush of the waves in the cavities, driving before them a volume of air, produces a sharp concussion, whence the name 'Crackers'. Always a favourite horizon for the fossil-collector, the Crackers have furnished a wealth of material for museums and private cabinets. They are the source of many of Forbes's and Woods's type-specimens of mollusca and have provided material for description by Withers (1945) of the minute crab *Vectis wrighti* and the cirripede *Virgiscalpellum wrighti* and by White (1927) of the pycnodont fish *Gyrodus atherfieldensis*. Finds by Wright and Wright (1942*b*; 1950*a*) also include the earliest known *Cretiscalpellum* and further examples of the cephalopod *Conoteuthis*, shown by Spath (1939*a*) to be the phragmocone of a peculiar belemnite with a very short guard. Echinodermata are represented by *Trochotiara fittoni* and ossicles of the starfish *Lophidiaster*. Brachiopods are seldom found. Some of the commoner or more interesting mollusca are—Cephalopoda: *Ancyloceras mantelli*, *Aconeceras nisoides*, *A.* cf. *haugi* (all very rare), *Deshayesites forbesi* sp. nov., *D. callidiscus* sp. nov., *D. topleyi*, *Roloboceras hambrovi*, *R. perli*, *Conoteuthis vectensis*, *C. dupiniana*. Lamellibranchia: *Aptolinter aptiensis*, *Cucullaea fittoni*, *Gervillella sublanceolata*, *Brachidontes vectiensis*, *Yaadia nodosa*, *Thetironia minor*, *Nemocardium* (*Pratulum*) *ibbetsoni*, *Protocardia anglica*, *Mactromya vectensis*, *Mediraon sulcatum* sp. nov., *Venilicardia saussuri*, *V. anglica*, *Vectianella vectiana*, *Resatrix parva*, *R.* (*Vectorbis*) *vectensis*, *Scittila nasuta*, *Senis wharburtoni*, *Pholadomya gigantea*, *P. martini*. Gastropoda: *Sulcoactaeon marginata*, *Tornatellaea aptiensis*, *Ovactaeonina forbesiana*, *Globularia cornueliana*, *Anchura* (*Perissoptera*) *glabra*, *A.* (*P.*) *robinaldina*, *Tessarolax moreausianum*, *T. fittoni*, *Dimorphosoma ancylochila*, *D. kinklispira*, *Uchauxia forbesiana*, *Mesalia* (*Bathraspira*) *neocomiensis*, *Turritella* (*Haustator*) *dupiniana*, *Cassiope pizcuetana* (very rare). *Deshayesites* makes up the greater part of the ammonite fauna, there being many undescribed species. *Roloboceras* is much less frequent and in my experience is restricted to the lower tier of concretions. The Crackers and the Upper Lobster Beds are taken together as the topmost part of the *forbesi* Zone with *D. callidiscus* as the subzonal index. This is the least rare of the ammonites confined to this horizon, though the overwhelming dominance of *D. forbesi* itself is the chief feature of this subzone.

The Upper Lobster Beds, 40 feet thick, were divided by Fitton into five beds (beds 6–10) of approximately equal thickness. They consist of alternations of brown-weathering, grey silty clay and grey sandy clay. Fossils are much less frequent than in the Crackers or the Lower Lobster Bed, though the crustacean *Meyeria magna* and the echinoid *Toxaster fittoni* are usually present. Washed samples of the clays yield a few foraminifera. Ammonites occur crushed flat in the clay or as internal moulds in clay-ironstone or iron pyrites; the last are prone to decomposition. *Deshayesites forbesi* is found in all the beds; other ammonites (many undescribed), due either to accidents of collecting or natural restriction, are known only from certain beds. *Sanmartinoceras (Sinzovia) aptiana*, *Pseudosaynella* cf. *fimbriata*, and *P.* aff. *undulata* have been found in bed 10 and nowhere else in the Lower Greensand. At the base of this bed are large *Deshayesites* encrusted with serpulae.

Ferruginous Sands. The Ferruginous Sands begin with Fitton's Lower Gryphaea Group (Group IV), which is divisible into three beds, as follows:

Section of the Lower Gryphaea Group of Atherfield

	ft.	*in.*
3. Firm dark reddish-brown sand with polished fragments of ironstone. The top 2–3 ft. full of large *Exogyra latissima* and clusters of pebbles cemented by black phosphorite	10	0
2. Coarse brown sand, crowded with brachiopod shells (*Sellithyris sella* and *Sulcirhynchia spp.*)	2	0
1. Grey-green, glauconitic, clayey sands, weathering brown, with rusty streaks; portions of the sand are indurated into spherical nodules up to the size of a football, some impregnated with phosphorite	16	0
Total	28	0

The nodules of bed 1 are crowded with fossils in a good state of preservation, with many small gastropods and lamellibranchs like those in the Crackers and the ammonites *Deshayesites deshayesi*, *D. consobrinoides*, *D. multicostatus*, *D.* cf. *involutus*, *Cheloniceras sp.*, *Toxoceratoides royerianus*, *T.* cf. *fustiformis*. This fauna has much in common with that of the Argiles à Plicatules of Bailly-aux-Forges (Haute-Marne), in the Paris Basin, the type locality of *Deshayesites deshayesi*, and its discovery at the base of the Ferruginous Sands is a big step forwards in the study of the Lower Greensand succession.

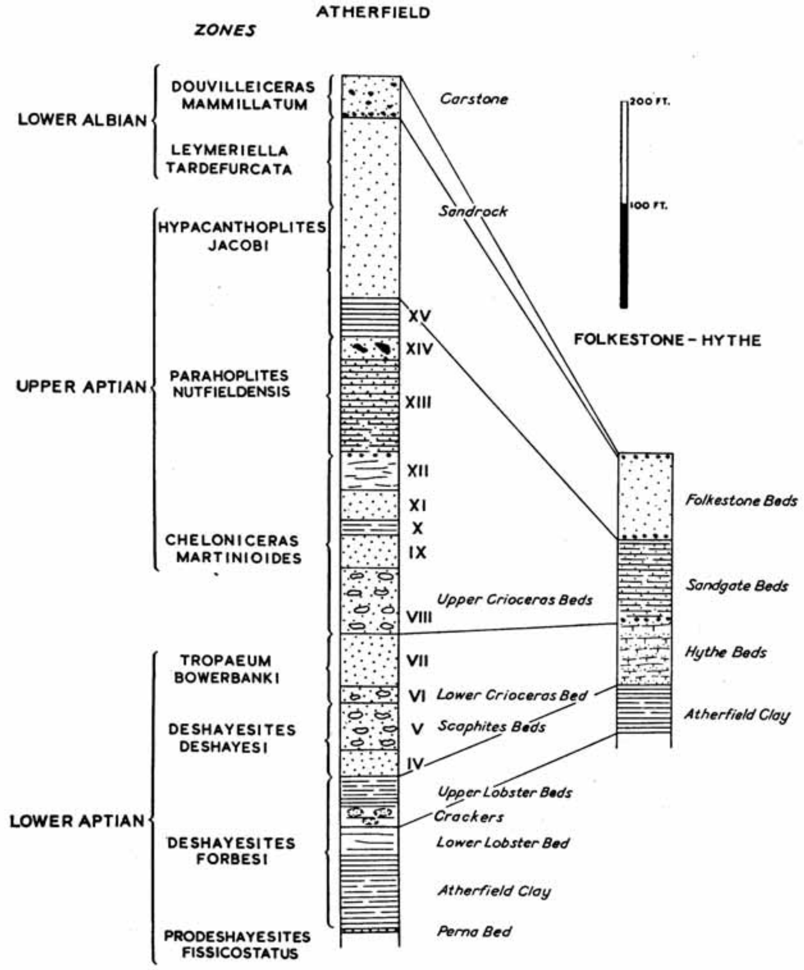
The '*Terebratula* bed' (bed 2) contains a profusion of brachiopods with a few *Exogyra*, *Gervillaria* and polyzoa, and little else. Fitton noted the abundance of *Pinna robinaldina* at the bottom of the overlying sand (bed 3), which also yields large examples of *Exogyra latissima* ('*Gryphaea*') and *Prohinnites favrinus*. A few phosphatized and semi-phosphatized specimens of *Cheloniceras parinodum* sp. nov. and *Deshayesites* cf. *involutus* have been collected and the pebble-clusters at the top frequently enclose a sheaf of *Serpula* tubes. This Lower Gryphaea Group is the *parinodum* Subzone of the *deshayesi* Zone of my classification. It was misnamed the '*grandis*-bed' by Spath in the belief that it was the source of the common *Deshayesites grandis*.

The top of the Lower Gryphaea Group forms a ledge slanting across the beach about 350 yards west of Whale Chine and makes a good datum-line for identification of the next set of beds, the Scaphites Group (Group V) of Fitton, detailed below.

Section of Scaphites Group of Atherfield, west of Whale Chine

	ft.	*in.*
4. Dark grey-green, glauconitic muddy sand with large *Exogyra latissima* at top	c.27	0
3. Large red-stained calcareous concretions (up to 2 ft. in length) disposed roughly in two lines. Much calcite in veins and covering fossils . . .	5	0
2. Brown-weathering, grey-green, glauconitic sand. A few indurated nodules .	18	0
1. Nodules of grey, argillaceous and sandy phosphorite, crowded with fossils .		2–4
Total about	50	0

The nodules at the base, not previously recorded, are rich in small fossils: juvenile gastropods (especially *Anchura*), tellinids, venerids, ammonite young and nuclei and serpulae. Heteromorph ammonites such as *Toxoceratoides royerianus* and *T.* cf. *fustiformis* are common,



TEXT-FIG. 2. Comparative sections of the Lower Greensand of Atherfield, Isle of Wight, and of the Folkestone–Hythe area of Kent.

together with *Deshayesites grandis*, species of *Cheloniceras*, and, rarely, *Aconeceras* cf. *nisoides*. Carbonized leaf impressions of *Weichselia reticulata* also occur. *Deshayesites grandis*, *Australiceras gigas*, *Cheloniceras cornuelianum*, and *Ch. crassum* are found in the nodules in bed 2, but the principal source of fossils in this Group is the large concretions of bed 3. When the foreshore is clear of shingle they may be seen to crop out in a band from the foot of the cliff to the water's edge, each balanced on a pedestal of the underlying sand like so many giant mushrooms. Split open, almost every one reveals a large ammonite as its nucleus of growth, either the ancyloceratid *Australiceras* ('*Scaphites*'), or *Deshayesites* or *Cheloniceras*, from 1 to 2 feet across. Smaller fossils occur in the matrix of the larger ones, including the nautiloids *Cymatoceras pseudoelegans*, *Eucymatoceras plicatum*, the lamellibranchs *Panopea gurgitis*, *Sphaera corrugata*, *Pterotrigonia mantelli anterior*, *Pseudaphrodina ricordeana*, the echinoids *Tetragramma malbosi* and *Hyposalenia wrighti*, and the crustacean *Homarus longimanus*. The following ammonites have been identified: *Australiceras gigas*, *A. sp. nov.*, *Epancyloceras hythense*, *Tonohamites decurrens*, *Cheloniceras cornuelianum*, *Ch. crassum*, *Ch. kiliani*, *Ch. spp. nov.*, *Deshayesites grandis*, *D. vectensis*, *D. spp. nov.* The oft-quoted record of *Tropaeum hillsi* in this bed or that above (bed 4) has not been confirmed. On account of the frequency of *Deshayesites grandis* this Group is designated the *grandis* Subzone of the *deshayesi* Zone.

The Lower Crioceras Bed (Group VI), 16 feet 3 inches thick, contains concretions arranged in irregular lines and embedded in grey-green muddy sand. With them are smaller, intensely hard, concretions of dark-brown or black phosphorite veined with calcite, each a nest of fossils. In the top of the Group ammonites occur incompletely phosphatized, the unphosphatized portions being crushed flat in the sand. The upper part of the Group comes down to the shore to form ledges at the mouth of Whale Chine. Ammonites collected from this bed are: *Tropaeum bowerbanki*, *Id.* var. *densistriatum*, *Australiceras gigas*, *Tonohamites decurrens*, *Cheloniceras cornuelianum*, *Ch. crassum*, *Ch. spp. nov.*, *Dufrenoyia furcata*, *D. truncata*, *D. lurensis*, *D. transitoria* sp. nov. *D. spp. nov.* Part of this assemblage has ranged up from the Scaphites Beds, but the ammonite fauna as a whole is quite distinct, characterized by the incoming of giant crioceratitid *Tropaeum* and the replacement of *Deshayesites* by *Dufrenoyia*. The rest of the fauna is similar to that of the Scaphites Beds, composed mainly of long-ranging lamellibranchs and the ubiquitous Lower Aptian brachiopod *Sellithyris sella*. This is the *transitoria* Subzone of the *bowerbanki* Zone.

Next above is the Walpen Clay and Sand (Group VII), divided as follows:

Section of Walpen Clay and Sand (Group VII) at Whale Chine

	ft.	*in.*
2. Grey sandy clay with small nodules of phosphorite and pyrites	33	0
1. Dark greenish-grey muddy sands and sandy clay with phosphorite concretions	24	0
Total	57	0

The phosphorite concretions of bed 1 are from 2 to 6 inches in diameter and contain numerous fossils. Near the bottom of the bed they are compact and difficult to crack open, like those in the bed below; above they are less dense and fall to pieces under the hammer. *Tropaeum bowerbanki* occurs at intervals through the sand and the nodules contain *Cheloniceras cornuelianum*, *Ch. crassum*, *Ch. meyendorffi*, *Dufrenoyia furcata*, *D. lurensis*, *Tonohamites aequicingulatus* with many lamellibranchs, including *Cucullaea cornueliana*, *Thetironia minor*, *Panopea gurgitis*, *Chlamys robinaldina*, *Resatrix hythensis*, and *Arca dupiniana*. This lower part of Group VII is accessible at the bottom of Whale Chine and forms the undercliff that runs south-eastwards to Ladder Chine. Its junction with the overlying sandy clay of bed 2 is marked by a line of water seepage. Fossils are much less numerous in bed 2 and are mostly phosphatized ammonite body-chambers. *Dufrenoyia lurensis*, *Ch. meyendorffi*, and an obese variety of *Ch. kiliani* have been found. Group VII is the upper half of the *bowerbanki* Zone (*meyendorffi* Subzone) and marks the top of the Lower Aptian.

The Upper Aptian part of the succession commences with the Upper Crioceras Beds (Group

VIII), about 46 feet of grey, brown-weathering, clayey sand with four or more ranges of big concretions. The top of the Group reaches the beach east of Walpen Chine, but the best exposures are in Whale Chine, where one can climb the slopes to collect *in situ* or forage among the tumbled blocks in the bottom of the Chine. *Cheloniceras* (*Epicheloniceras*) *martinioides* and *Ch.* (*E.*) *debile* spp. nov. are the characteristic ammonites; *Ch.* (*E.*) *tschernyschewi* occurs rarely. Giant ancyloceratids, formerly included in '*Crioceras*' *bowerbanki*, are represented by *Tropaeum benstedi* and an undescribed *Ammonitoceras*. *Gervillella sublanceolata*, *Panopea gurgitis*, *Yaadia nodosa*, *Linotrigonia* (*Oistotrigonia*) *ornata*, *Venilicardia sowerbyi*, and *Anchura* (*Perissoptera*) *robinaldina* are some of the other molluscs found here. Fossils tend to lie in clusters in the rock, which is often impregnated with calcite and contains scattered bits of drift-wood and fronds of *Weichselia*. These beds are the *debile* Subzone of the *martinioides* Zone.

The Walpen and Ladder Sands (Group IX) are 42 feet of greenish and grey sand with a line of gritty calcareous concretions at the base, olive-green in colour. About 18 inches thick and up to 4 feet long, these concretions each enclose a rounded mass of brown phosphorite full of fossils. They come down to beach level east of Walpen High Cliff and break into a line of boulders running out to sea. Heavy hammer and chisel are needed to extract the fossiliferous cores, many of which are graveyards of small ammonites, usually young *Epicheloniceras*, or colonies of *Sellithyris*. Secondary calcite invades all the cracks and cavities, lining the insides of brachiopods and producing casts of ammonite phragmocones. Ammonites include *Ammonitoceras sp. nov.*, *Australiceras sp.*, *Ch.* (*E.*) *tschernyschewi*, *Ch.* (*E.*) aff. *volgense*, *Ch.* (*E.*) *gracile* sp. nov., *Ch.* (*E.*) *spp. nov.*, *Aconeceras* cf. *nisum*, and an unnamed genus and species of Aconeceratidae. The lamellibranchs *Inoceramus neocomiensis*, *Resatrix parva*, *Modiolus aequalis*, *Thetironia minor*, the gastropod *Chilodonta* (*Agathodonta*) *dentigera*, the echinoids *Phyllobrissus fittoni* and *Toxaster fittoni*, and a large *Serpula* are also characteristic. About 6 feet higher is a thin sandstone ledge with masses of intertwined serpulae, but the remaining thickness of sand is poor in fossils. The whole Group, together with the overlying Group X, comprises the *gracile* Subzone of the *martinioides* Zone.

Group X, the Upper Gryphaea Beds, includes about 16 feet of ferruginous clayey sands with bands of *Exogyra latissima* in the lower 12 feet. It crops out in a mural cliff-face and is difficult to work. Fitton mentioned the presence of nodules with '*Ammonites martini*' about 4 feet from the base; the only fossils I have seen at this level are badly preserved cheloniceratids resembling those at the base of Group IX and a few long-ranging lamellibranchs. Plant debris, with fronds of *Weichselia*, occurs throughout.

The succeeding 28 feet of glauconitic sands and clays that comprise Fitton's Cliff-end Sand (Group XI) is divisible into two beds of equal thickness. At the base of the lower bed are some ferruginous gritty lumps embedded in a more argillaceous matrix and with much carbonized plant debris; their poorly preserved fossils include *Cheloniceras* (*Epicheloniceras*) cf. *buxtorfi* and tiny aconeceratids. Two feet higher is the thin clay seam from which Fitton recorded *Trigonia*, and near the top of this lower bed are said to be concretions with *Pinna*. The upper half of Group XI is chiefly remarkable for its cylindrical, branching concretions and lenses of current-bedded greensand and is barren to the palaeontologist. No fossils have been found in the next Group, the Foliated Clay and Sand (Group XII). This consists of 35 feet of interlaminated glauconitic sand and dark-blue pyritic clay, with some lenticular masses of coarse, current-bedded, friable sandstone capped by 10 feet of white sand and sandstone, giving a depressing preview of the great thickness of unfossiliferous sands encountered in the Sandrock high above. These last two Groups are assigned with question to the *buxtorfi* Subzone, the topmost part of the *martinioides* Zone.

Glauconitic pale-green, yellow, and brown sands, about 90 feet thick, form the Sands of Walpen Undercliff (Group XIII) and occupy the base of the cliff for about 700 yards below

Blackgang Chine. I agree with Kirkaldy (1939, p. 394) in drawing the lower limit of this Group at the conspicuous pebble-bed (bed 42*a* of Fitton), the underlying 10 feet ('First Sandrock') being better accommodated in Group XII. At about the middle of this Group, 200–250 yards east of the cascade at Blackgang Chine, large fossiliferous nodules with moulds of rhynchonellids, and *Pterotrigonia mantelli*, *Thetironia minor*, immature *Parahoplites* and other molluscs, weather out at the foot of the cliff. Similar nodules are found fresh in the same Group at Horse Ledge, Shanklin, where they yield a larger fauna of ammonites denoting the *subarcticum* Subzone of the *nutfieldensis* Zone.

The Ferruginous Bands of Blackgang Chine (Group XIV) consist of about 20 feet of brown and yellow sands with three ranges of iron concretions abounding in moulds and impressions of fossil shells. These sands rise from the shore about midway between Blackgang Chine and Rocken End and the topmost range of concretions is responsible for the cascade in the Chine. Lengthy lists of fossils from this Group have been published by Fitton and Norman; the latter author (1887, p. 47) records *Iguanodon* remains. Lamellibranchs and gastropods make up the bulk of the fossiliferous masses, the following being especially characteristic: *Thetironia minor*, *Lucina cornueliana*, *Pterotrigonia mantelli*, *Cucullaea cornueliana*, *Senis wharburtoni*, *Resatrix parva*, *Parmicorbula striatula*, *Globularia sublaevigata*, and *Anchura* (*Perissoptera*) *robinaldina*. Drift-wood occurs and Norman mentions the presence of cycads. No cephalopods have been recovered here from this Group despite the profusion of other molluscs, and its position in the *cunningtoni* Subzone of the *nutfieldensis* Zone is inferred from finds elsewhere. The overlying 40 feet of dark-grey sandy clay, included by Fitton in his Group XV, and apparently equivalent to the Marehill Clay of the Pulborough region, is without recognizable fossils. It may represent the *nolani* Subzone of the *jacobi* Zone.

Sandrock. This division here attains a thickness of 186 feet and is composed of white and yellow quartz sand and sandrock. Apart from a little plant debris the beds are practically barren of organic content, though Lamplugh (1901) recorded the discovery in the slopes south-east of Blackgang Chine of a band of ferruginous concretions with casts of marine bivalves 10 feet below the top of the division. Like Jackson (1939, p. 74) I have searched in vain for these concretions, though the precipitous nature of the slopes, vegetation, and downwash from the Gault prevent a critical examination of the section. This part of the succession must fall within the *jacobi* and *tardefurcata* Zones.

Carstone. This division forms the top of the Lower Greensand, consisting of 12 feet of gritty reddish-brown sands with pebbles and phosphatic nodules, and rests with sharp junction on the sands below. It is accessible in the Undercliff near Blackgang and in tumbled blocks on the beach far below. I have collected *Anadesmoceras baylei* from the pebbly basement-bed and the Museum of Isle of Wight Geology possesses a fine example of *Sonneratia kitchini* in a Carstone matrix picked up from the beach.

In the vicinity of St. Catherine's Point the Lower Greensand is hidden beneath a mantle of slipped Gault and Upper Greensand, but here and there the top of the Sandrock and the Carstone may be seen in low cliffs and shore-ledges, and boulders of Carstone strew the floors of the coves. In Reeth Bay, Puckaster Cove, and in Watershoot Bay the beach includes lumps of phosphorite-cemented grit and pebbly sand from which Jackson (1939) recorded the discovery of fossils by a local fisherman, Mr. G. R. Haynes. These nodules, which may now be seen *in situ* in Reeth Bay, originate in the Carstone and have yielded a large fauna of *mammillatum* Zone age. The ammonites comprise several species of *Sonneratia*, together with *Anadesmoceras baylei*, *Beudanticeras dupinianum*, *Otohoplites sp.*, and *Douvilleiceras mammillatum*. *Inoceramus coptensis* sp. nov., *Cuneolus lanceolatus*, *Entolium orbiculare*, *Anthonya cantiana*, *Senis wharburtoni*, and *Pinna robinaldina* are among the lamellibranchs found here;

gastropods are represented by *Claviscala clementina*, *Tessarolax fittoni*, *Gyrodes genti*, *Anchura* (*Perissoptera*) cf. *parkinsoni* and *Semisolarium moniliferum;* echinoids by *Toxaster murchisonianus*, *Holaster* (*Labrotaxis*) *cantianus*, and *Polydiadema* cf. *wiltshirei*. The nodules in Reeth Bay yielded a unique dromiacean crab, *Plagiophthalmus nitonensis* (Wright and Wright 1950*b*).

Compton Bay. At Compton Bay the Lower Greensand is not only much thinner than at Atherfield but the beds have changed in character, so that precise correlation is impossible. Fossils are very scarce above the Perna Beds and the only ammonites that have been obtained from the main mass of the strata are insufficient to prove more than the presence of the *bowerbanki* and *martinioides* Zones. From the pebble-bed at the base of the Carstone the Wright brothers collected a small suite of rolled and phosphatized ammonite fragments, including *Sonneratia parenti* and *Cleoniceras morgani*, both forms of the *mammillatum* Zone.

Redcliff. The whole thickness of the Lower Greensand is exposed at Redcliff, on the north side of Sandown Bay, but the cliffs are deeply weathered, fossils are much rarer, and above the Atherfield Clay it is impossible to make out the detailed zonal succession established at Atherfield.

The Perna Beds and the lower part of the Atherfield Clay have for many years been accessible in a large cliff-founder north of Yaverland Fort. The Perna Beds form a solid rib of rock at the base of the cliff and break down into boulders over the beach. They are a rich source of fossils and have contributed the following ammonites: *Prodeshayesites obsoletus* gen. et sp. nov., *P*. sp. nov. aff. *laeviusculus* (v. Koenen), *P. spp. indet*., *Deshayesites spp. nov*. All these were found in the grey-green calcareous stone at the top of the beds (bed 3 of Atherfield) and a pyritic mould of *P. obsoletus* was found also in the underlying sandy clay (bed 2 of Atherfield). In all other respects the occurrence is identical with that of the Perna Beds of Atherfield and has furnished large quantities of fossils for museums.

The basal few feet of the Atherfield Clay contain species of *Prodeshayesites*, *Roloboceras*, and *Deshayesites*, the last including *D. forbesi* and *D. fittoni*. Museum material suggests that representatives of the Crackers and Lobster Beds are present here, though these beds cannot be delimited in the section now visible. Black phosphatic body-chambers of *Dufrenoyia* similar to those in the Lower Crioceras Bed at Atherfield have been found among the beach pebbles, but their source has not been located. A conspicuous band of pebbles with derived Jurassic fossils, mainly Kimmeridgian *Pavlovia*, occurs about 50 feet below the top of the Ferruginous Sands, apparently on the same horizon as that seen at the base of Group XIII at Atherfield. No fossils have been found in the Sandrock at this locality, and the Carstone, which here reaches its maximum thickness of 72 feet, is similarly barren.

Shanklin. Under this heading will be considered the long stretch of Lower Greensand that appears on the coast between Sandown and Bonchurch, near Ventnor.

The Perna Beds, formerly seen on the shore near Sandown Pier, are no longer exposed and the Atherfield Clay is built over. Excavations made in April 1950 during extension of the Trouville Hotel, 200 yards north-east of the Pier, yielded to Mr. J. Barker (1952) a few crushed *Prodeshayesites* and *Deshayesites* from the bottom 4 feet of the Atherfield Clay.

No distinctive organic remains have been found in the lower part of the Ferruginous Sands, displayed in the cliff south of Sandown, but at Lake Stairs, in division 1 of Osborne White (1921, p. 37), *Tropaeum bowerbanki*, *Cheloniceras cornuelianum*, and *Dufrenoyia furcata* have been found in ferruginous concretions, indicating the *bowerbanki* Zone of the Lower Aptian. Another three-quarters of a mile south, near the slipway at Little Stairs, the top of his division 2 slants down to the shore. Here at low tide may be seen a band of discoidal concretions with impressions of large *Tropaeum* and *Epicheloniceras*. Osborne White was probably right to correlate this band with the Upper Crioceras Beds of Atherfield.

Forty-six feet above the last horizon and 4 feet below a tabular band of ironstone, 100 yards south of the slipway, the sands contain rotted nodules with fossils, some being nests of small *Epicheloniceras* like those in Group IX at Atherfield. Above this level the sands are riddled with vacant moulds of *Exogyra*, strongly suggestive of the Upper Gryphaea Beds (Group X) of Atherfield.

At Small Hope Chine may be seen glauconitic sand with clusters of *Exogyra latissima* and *Lopha diluviana*, apparently the upper part of Osborne White's division 3, identified by Fitton with part of Group X. Blocks of orange-coloured ironsand fallen from division 5 lie on the shore at Little Stairs Point and yield numerous *Exogyra tuberculifera* and *Lopha diluviana*, together with the echinoid *Trochotiara fittoni* and polyzoa. In the cliffs south of Shanklin Chine *Exogyra latissima* is found in the sands singly and in bands. Running out from the foot of Shanklin Point and forming the southern part of Horse Ledge is a prominent band with *Exogyra* and knobs of speckled greensand full of white fossils, best seen at low tide. Many of the knobs are a solid mass of brachiopoda or arborescent polyzoa (*Siphodictyum gracile*, *Chisma furcillata*, *Choristopetallum impar*, &c.) or *Serpula*. This is the 'Urchin Bed', probably the most important source of echinoids in the Lower Greensand, as the following list indicates: *Toxaster fittoni*, *T. renevieri*, *Phyllobrissus fittoni*, *Catopygus vectensis*, *Holaster wrighti*, *Tetragramma rotulare*, *Trochotiara fittoni*, *Hyposalenia wrighti*, *H. stellulata*. Lamellibranchs are represented by long-ranging species, *Thetironia minor*, *Pterotrigonia mantelli*, &c., but there are a few distinctive gastropods, such as *Ringinella albensis*, *Dimorphosoma vectianum*, *Confusiscala ischyra*, and *Claviscala ricordeana*. Ammonites are found only in fragments or in immature examples: *Parahoplites* cf. *maximus*, *P.* cf. *nutfieldensis*, *P. sp. nov.*, and *Tropaeum subarcticum* fix the horizon as the bottom part of the *nutfieldensis* Zone. Middlemiss (1959) lists the following brachiopods from this bed: *Rhombothyris extensa*, *Platythyris comptonensis*, *Sellithyris sella shanklinensis*, *Cyrtothyris uniplicata*, *Praelongithyris praelongiforma*, *Oblongarcula oblonga*, '*Ornithella*' *morrisi*, '*O.*' *celtica*, '*O.*' *tamarindus*, '*O.*' *wanklyni*, '*O.*' *juddi*?, *Sulcirhynchia hythensis*, '*Rhynchonella*' *parvirostris*, and *Lingula truncata*.

The succeeding 20 feet of argillaceous greensand contains the ferruginous concretions for which Shanklin has long been famed. This part of the sequence is the obvious correlative of the Ferruginous Bands of Blackgang Chine (Group XIV), the concretions having an identical fauna of lamellibranchia and gastropoda in the same mode of preservation. Fossils occur as moulds, in subspherical masses, so tightly packed as to leave little room for matrix. At Shanklin they have produced a few rare specimens of *Parahoplites* that indicate the *cunningtoni* Subzone of the *nutfieldensis* Zone. This is also the type horizon and locality for the limpets *Acmaea formosa* and *Helcion meyeri* Gardner (1877*a*). As at Atherfield, no fossils have been found in the thick band of clay that terminates the Ferruginous Sands.

The overlying Sandrock, nearly 120 feet thick, is very clearly displayed in Luccomb Chine and Knock Cliff. Twenty feet above the base is a band of green clayey grit, 8 feet thick, with a seam of phosphatic and pyritic nodules and fossil wood at the bottom. The bed is most readily seen at the mouth of Luccomb Chine, where the beach is strewn with wood from the basal nodular seam. This is the site of the famous plant discovery that enabled Carruthers (1870) to diagnose an extinct order of Cycadophyta, the Bennettitales, more complex and specialized than the living cycads. In addition to *Bennettites gibsonianus* and *B. maximus*, the flora contains many conifers (*Cupressinoxylon vectense*, *C. luccombense*, *Sequoia giganteoides*, *Cedrostrobus leckenbyi*, *Podocarpoxylon gothani*, *P. solmsi*, *Pityostrobus jacksoni*) and wood of uncertain affinities (*Vectia luccombensis*) (Carruthers 1869; Barber 1898; Stopes 1915; Creber 1956). The type specimen of the angiosperm *Aptiana radiata* almost certainly originated here. Much of the wood is riddled with *Terebrimya* borings and appears to have been long adrift. Discovery of rare *Hypacanthoplites rubricosus* in the nodules now fixes the horizon of this important plant bed in the lower part of the *jacobi* Zone. The only other locality where I have found the *rubricosus* fauna is at the bottom of the Folkestone Beds of Folkestone. Lamplugh's view that the lower half of the Sandrock should be correlated with the upper part of the Sandgate Beds of the mainland (Lamplugh 1901, p. 119) is thus not supported.

On the shore at Dunnose Professor H. L. Hawkins picked up a nodule containing a hollow mould of *Hypacanthoplites* aff. *trivialis*, apparently derived from the top of the Sandrock. This find is interesting in view of the record of fossiliferous nodules at the top of the Sandrock at Blackgang Chine (Lamplugh 1901) and suggests correlation with the *milletioides* Subzone of Sandling Junction. That the Sandrock is followed immediately by the *mammillatum* Zone is proved by the occurrence of *Sonneratia kitchini* and allied species in the basement-bed of the Carstone at Dunnose and in the few feet of grits above. *Beudanticeras newtoni* nom. nov. and rare *Otohoplites* and *Protohoplites* have been collected from fallen blocks between Dunnose and Bonchurch. Added to the finds around Reeth Bay, they show that all subzones of the *mammillatum* Zone are present in the Isle of Wight. The junction with the Gault is gradational and ammonites of the *eodentatus* Subzone of the Middle Albian still occur in a gritty Carstone matrix.

Dorset Coast

The Lower Greensand of the Dorset coast is a condensed version of that seen in the Isle of Wight. The best section is in Punfield Cove, at the north corner of Swanage Bay, where the beds were first studied in detail by Judd (1871) and Meyer (1872). Judd thought they were part of a transition series between fresh-water Wealden and marine Lower Greensand (or 'Neocomian'), for which series he proposed the name *Punfield Formation*. This idea was promptly contested by Meyer, who showed that, as in the Isle of Wight, the beds at Punfield could be easily divided into Wealden Shales below and Lower Greensand above. The accuracy of Meyer's correlation is now generally acknowledged: it may now be shown that Judd, too, was not wholly incorrect in his conception of a passage from one formation to the other, for although the 'Punfield Formation' does not exist as a stratigraphical unit, the Lower Greensand does take on a brackish-water facies and merges into the Wealden when followed westwards along the Dorset coast.

The succession at Punfield is as follows (Strahan 1898; Arkell 1947*b*; House 1958):

Lower Greensand at Punfield

		ft.	*in.*
Ferruginous Sands			
15. Yellow sand, not well seen	about	10	0
14. Clay, dark, sandy, selenitic		15	0
13. White sandstone with quartz pebbles		20	0
12. Brown sandstone and yellow sandstone with shales		15	0
11. Interlaminated sand and clay; worm burrows?		15	0
10. Ferruginous sand and hard irony sandstone with *Nuculana*		12	0
9. Interlaminated sand and yellow clay with some thicker beds of yellow and white sand		61	0
Punfield Marine Band			
8. Fossiliferous limestone with wavy seams of lignite		1	0
Atherfield Clay			
7. Clay, reddish above, blue and very fossiliferous in lower part		28	0
6. Sandstone, soft yellow, with lamellibranchs		1	0
5. Clay, pale red, bluish in parts		8	6
4. Sandstone in four hard grey bands		3	0
3. Clay, red		6	0

Pebble Bed

		ft.	*in.*
2.	Sand, dark green, with small pebbles and grit	1	0
1.	Pebbly clay, pale blue, sandy; small rolled bivalves, ammonites, &c., and larger pebbles of sandstone, wood, &c., at base	2	0
	Total	198	6

Strahan correlated the Pebble Bed with the Isle of Wight Perna Beds, but Arkell thought it possible that the pebbly basement-bed of the Lower Greensand is diachronous, becoming younger westwards. On the other hand, it is possible that the Pebble Bed of Punfield corresponds only to the gravelly seam at the base of the Isle of Wight Perna Beds, that the clay above (bed 3) is the clay of bed 2 of the Perna Beds of Atherfield, and that the sandstone referred to the Atherfield Clay (bed 4) is really the calcareous sandstone at the top of the Perna Beds of Atherfield. In the absence of indigenous ammonites nothing can be proved.

Arkell's faunal list (1947*b*, pp. 171–2) shows the Pebble Bed and Atherfield Clay to possess many small lamellibranchs found also in the Atherfield Clay Series of the Isle of Wight, such as *Nuculana scapha*, *Aptolinter aptiensis*, *Pseudoptera subdepressa*, *Freiastarte subcostata*, *Panopea gurgitis*, and *Plectomya anglica*. *Mulletia mulleti* and the other large molluscs do not occur. The zone fossil *Deshayesites forbesi* (*D. deshayesi* in Arkell) was found in abundance in bed 7, apparently the equivalent of the Lower Lobster Bed of Atherfield. The chief palaeontological interest in this section, however, is in the Punfield Marine Band. This thin band of limestone, full of lignite, contains a rich fauna, including the ammonites *Deshayesites forbesi*, *D.* aff. *callidiscus*, *D. sp. nov.*, and *Roloboceras hambrovi*. All previous determinations of ammonites from this bed are incorrect (e.g. Arkell 1947*b*, p. 172); *Deshayesites punfieldensis* has not been found at Punfield and views as to the horizon and locality of this ammonite expressed by Spath were misleading. The ammonites are all Crackers species and they confirm Strahan's correlation of the Punfield Marine Band with that bed. But whereas ammonites are very abundant in the Crackers, they are exceedingly rare in the Punfield Marine Band. Conversely, the gastropod *Cassiope*, of brackish-water affinities and characteristic of the Punfield fauna, is known from the Crackers only in one or two examples. The lamellibranch genus *Eomiodon*, an indicator of marine-brackish conditions (Casey 1956), is present in the Punfield Marine Band (e.g. GSM 86398) though unknown in any of the beds at Atherfield. *Nemocardium* (*Pratulum*) *ibbetsoni*, a lamellibranch of very wide tolerance (being found both in the Wealden Shales and the Atherfield Clay Series), is quite common at Punfield. There is no doubt that the fauna of the Punfield Marine Band shows the influence of brackish-water and the few ammonites found in this lignitiferous bed may have been drifted or washed in.

Support for this view is forthcoming from the next exposures. About 5 miles west of Punfield Cove Geological Survey officers measured and collected from Lower Greensand exposed in a cutting on the west side of Corfe Station. The Punfield Marine Band was found, full of shell fragments and lignite, and the many fossils from this band, in the Geological Survey Museum, were listed by Arkell (1947*b*). Noteworthy features of the fauna are the absence of ammonites, the greater abundance and variety of *Cassiope*, plentiful *Nemocardium* (*P.*) *ibbetsoni*, and the presence of *Eomiodon*. Where the Lower Greensand comes down to the coast again, at Worbarrow Bay, about 6½ miles west of Corfe, the Punfield Marine Band has passed into a thin fossiliferous ironstone (Arkell 1947*b*, p. 176). Here *Cassiope* still occurs and is accompanied by larger and more numerous specimens of *Eomiodon* (*Astarte obovata* of Arkell) and an abundance of a small bivalve identified by Arkell as *Anthonya cornueliana* but here described as *Cuneocorbula arkelli* sp. nov. There are no ammonites. Finally, on the east side of Lulworth Cove, 1 foot below the Gault, is an impersistent band of ironstone, 6 inches thick, from which Strahan obtained '*Cyrena*', *Exogyra*, and a few gastropods and which he assigned to the Wealden. Arkell, however, pointed out its resemblance to the fossiliferous ironstones of

Worbarrow Bay and he and Kirkaldy (1939, in discussion) agreed in placing it in the Lower Greensand. A collection of fossils made recently by Mr. S. W. Hester from this ironstone was kindly passed to me for study. Their matrix is indistinguishable from the ironstone of Worbarrow Bay and might have been expected to contain the same fauna. Instead the fossils were all lamellibranchs and comprised *Exogyra* cf. *tuberculifera*, *Eomiodon* cf. *libanoticus*, and *Filosina gregaria*. The last is the common '*Cyrena*' of the Wealden Shales (Casey 1955*b*), while the species of *Exogyra* and *Eomiodon* are those found also in the Punfield Marine Band farther east. *Eomiodon* and *Filosina* are known in association elsewhere only in the Aptian of the Lebanon. Below this fossiliferous ironstone the beds at Lulworth Cove pass down without break into the Wealden (Strahan 1898, p. 129).

The interpretation placed on the above facts is as follows: towards the end of *forbesi* times a slight elevation of the land affected the easterly flowing river that discharged its sediment over the present Dorset–Isle of Wight area, causing the estuary to move eastwards. On the southwest coast of the Isle of Wight the movement was expressed by the interruption of the Atherfield Clay Series by a bed of sand (Crackers). Proceeding westwards on the Crackers horizon we travel up the estuary of the river, the fauna gradually changing as the waters become less saline, until, at Lulworth Cove, the water was sufficiently diluted to support lamellibranchs of Wealden facies. Here then is the passage of Lower Greensand into Wealden and, in some measure, the vindication of Judd's 'Punfield Formation'. That of all the Punfield beds, the 'Marine' Band should be the one to demonstrate a progressive brackish-water influence is unfortunate; it is another example of the misnomers so replete in geological literature.

Wealden Province

The Wealden Province is here taken to comprise not only the Cretaceous area of Kent, Surrey, and Sussex, which is the geological Weald proper, but also the areas of Lower Greensand deposition in Wiltshire and the adjacent counties. For convenience of treatment this larger Wealden Province may be divided into five regions, as follows:

(1) East Kent
(2) West Kent
(3) Surrey (with part of Hampshire)
(4) Sussex
(5) The western outliers

Conforming with the anticlinal structure of the Weald proper the Lower Greensand crops out in an elliptical band that continues from the coast at Folkestone through Kent, Surrey, and Sussex, encircling the Wealden Beds and ringed in turn by the narrow outcrop of the Gault. The beds were first studied in detail around Folkestone, where Fitton (1836) divided them into three broad lithological units. Subsequently the presence of a fourth unit underlying those recognized by Fitton was noted in Surrey by Austen (1843); this was later found to be widespread and was correlated by Fitton (1847) with the Atherfield Clay of the Isle of Wight. In the Geological Survey Memoir on the country between Folkestone and Rye the following names for the four divisions of the Lower Greensand were used by Drew (1864):

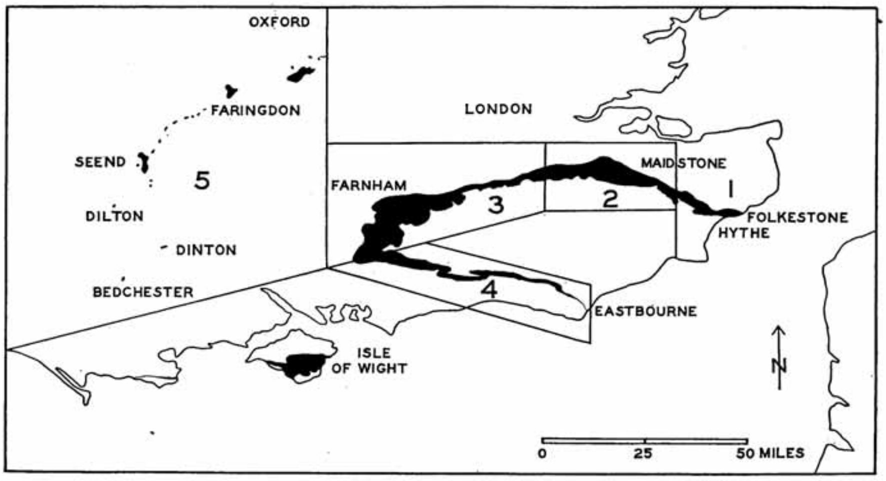
(4) Folkestone Beds
(3) Sandgate Beds
(2) Hythe Beds
(1) Atherfield Clay

This nomenclature was given a Weald-wide application by Topley (1875) and despite the fact that Topley himself was later a party to the proposal to merge the Folkestone and Sandgate Beds under the term 'Shanklin Sands' (Topley and Jukes-Browne 1888), it has remained in use for the succession in the Weald.

East Kent

Within the East Kent region the Lower Greensand crops out in a belt some 2 to 3 miles wide and about 18 miles long, extending from Folkestone in the east to Ashford in the west.

Previous work in this area has centred on the classic sections on and near the coast between Folkestone and Hythe (Fitton 1836; Drew 1864; De Rance 1868; Price 1874; Topley 1875; Spath 1923*b*, 1925, 1930*a*, 1935; Casey 1936, 1939, 1950). Gregory (1895) described the fauna of the base of the Sandgate Beds at Great Chart, near Ashford, and the relations of these beds to the underlying members of the Lower Greensand in East Kent were discussed by Kirkaldy (1937). Cornes and others (1925) contributed a brief account of the Lower Greensand of the Ashford district and similar accounts for the whole of East Kent have been published by Cornes (1928) and Kirkaldy (1939). The stratigraphy and petrographical characters of the beds have been more fully described by Worrall (1954).



TEXT-FIG. 3. Regional divisions of the Wealden Province. 1, East Kent; 2, West Kent; 3, Surrey (with part of Hampshire); 4, Sussex; 5, The Western Outliers.

Much was learnt about the underground extension of the Lower Greensand in East Kent from borings and shafts put down in search for coal (Lamplugh and Kitchin 1911; Lamplugh, Kitchin, and Pringle 1923). These show that the formation dwindles rapidly to the north and to the east. Nearly 300 feet thick at the outcrop, it is reduced to 50 feet 8 miles farther north and disappears altogether along a line running just north of the Stour Valley.

Atherfield Clay. This division consists of greenish-grey, brown, and blue silty clays, resting with sharply defined base on the Wealden Beds. It is poorly exposed at outcrop and knowledge of its palaeontological characters, thickness, and relations to the beds above and below has been obtained chiefly from the Kent Coalfield shafts and borings. Re-examination of the ammonites shows that in East Kent the Atherfield Clay represents the upper part of the *forbesi* Zone (*callidiscus* Subzone) and is the correlative of the Crackers and Upper Lobster Beds of the Isle of Wight, not of the Atherfield Clay s.s. This is shown by the abundance of *Deshayesites forbesi*, the presence of species of the *callidiscus* type, and the absence of any ammonite diagnostic of the Lower Lobster Bed or Atherfield Clay s.s. There is no Perna Bed at the base.

In the Dover shafts the Atherfield Clay was proved between depths of 388 and 431 feet and yielded a rich fauna, including many ammonites. The fossils were described by Kitchin (in Lamplugh and Kitchin 1911, pp. 107–11) and are now in the Geological Survey Museum. The long list of mollusca, echinoidea, and crustacea is duplicated at Atherfield, and, as at that locality, the base of the formation contains teeth of *Hybodus* and *Acrodus* apparently derived from the Wealden Beds. The dominant ammonite is *Deshayesites forbesi* sp. nov. (= *Hoplites deshayesi* of Kitchin), which occurs from top to bottom. Crushed and distorted fragments of an undescribed species of *Deshayesites* found also in the Upper Lobster Beds were collected at 410 and 415 feet (= cf. *Acanthoceras albrechti-austriae* and *Crioceras* sp. of Kitchin) and a few pieces of a feebly ornamented *Deshayesites* like *D. topleyi* or *D. callidiscus* sp. nov. were recovered between depths of 418 and 431 feet (*Hoplites laeviusculus* of Kitchin). The '*Douvilleiceras martini*?' recorded from 415 feet by Kitchin is an immature *Roloboceras*.

Deshayesites forbesi was found in numbers in the 25 feet of Atherfield Clay proved in the Guilford Colliery shaft, situated $1\frac{1}{8}$ miles north-east of Lydden Church, near Dover (Geological Survey and Brigadier Bomford collections) and the same species was found to characterize the Atherfield Clay in a boring recently put down at St. Margaret's Bay, north of Dover (Geological Survey collection). In the Brabourne boring, about 14 miles west of the Dover shafts, a fragmentary *Deshayesites*, apparently *D. forbesi*, was found between 240 and 250 feet. This is the ammonite recorded by Kitchin (ibid., p. 114) (as possibly *Crioceras*) from strata assigned to the Sandgate Beds. Not only does the ammonite show this correlation to be false, but its matrix and that of the associated fossils is identical with the Atherfield Clay in the Smeeth railway-cutting. This explains the unusually great thickness of the 'Sandgate Beds' in the Brabourne boring (98 feet) and disposes of the suggestion, frequently repeated, that the Hythe Beds have here passed into Sandgate Beds facies (Lamplugh and Kitchin 1911, p. 37).

A shaft sunk by Simms (1843) during the construction of the Saltwood railway tunnel, near Hythe, proved a thickness of 49 feet 6 inches of Atherfield Clay between the Hythe Beds and the Weald Clay. Fossils obtained from this shaft are in the Geological Survey Museum and include *Resatrix* and other lamellibranchs, but not *Mulletia mulleti*, as stated by Simms. The bottom of the clay yielded *D. forbesi* and the undescribed *Deshayesites* referred to above. The Survey collections also contain the ammonites *D. forbesi* and *Toxoceratoides* cf. *biplex* collected by H. B. Mackeson from the Atherfield Clay of Hythe. *D. forbesi* was also collected by Mr. B. C. Worssam from exposures of the clay in the banks and bed of Brockhill Stream, seven-eighths of a mile N. 65° W. of Hythe Church.

In 1925 a landslip in the railway-cutting half a mile west-north-west of Smeeth Station exposed the junction of the Atherfield Clay and the Hythe Beds. Specimens collected here by the Geological Survey show the Atherfield Clay as a pale-grey micaceous and silty clay with pyritous threads and with the ubiquitous *D. forbesi*. This occurrence is in flat contradiction to the statement of Cornes (1925, p. 260) that the slip revealed the Hythe Beds resting directly on Weald Clay. Since he also said (ibid., p. 259) that in this district the upper part of the Weald Clay contains 'a definitely marine mollusc—*Exogyra sinuata*', a common Lower Greensand species not otherwise recorded from the Wealden Beds, it may be suggested that Atherfield Clay was mistaken for Weald Clay. It is mainly on the word of Cornes that subsequent authors have pinned their faith on the discontinuity of the Atherfield Clay in the Ashford district (Kirkaldy 1939, p. 391; Worrall 1954, p. 187). Field evidence for the continuity of the Atherfield Clay in this area being open to dispute (see discussion in Worrall 1954), it is important to emphasize that in the critical section at Smeeth palaeontology puts the matter beyond argument.

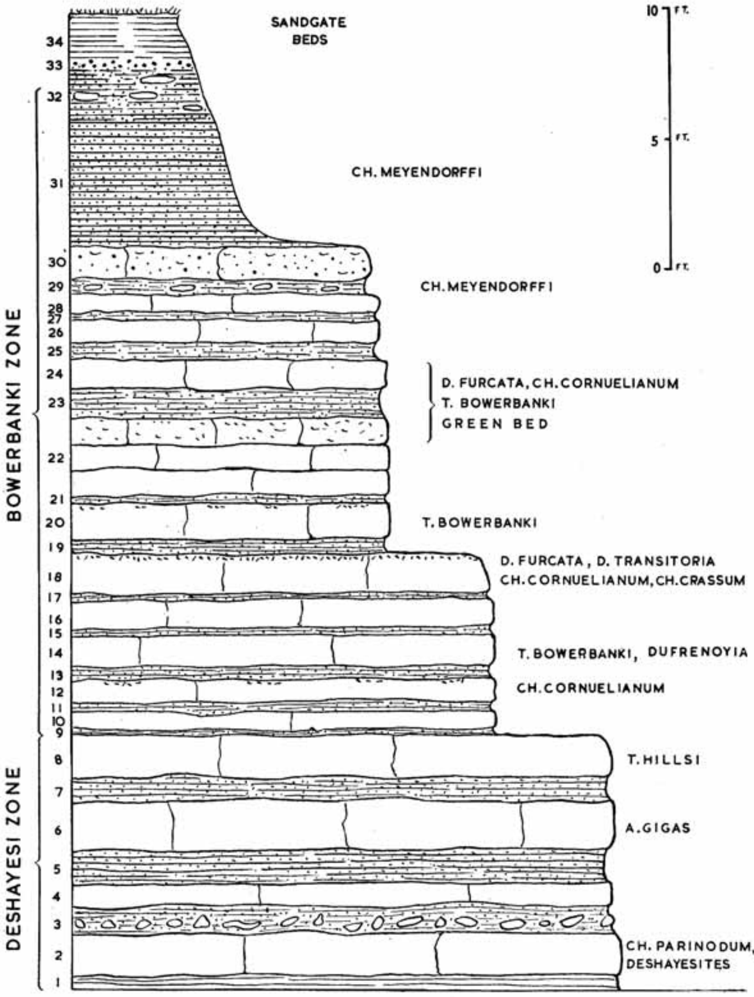
No fossils have been recorded from the marginal area of Atherfield Clay deposition in east Kent, as for instance in the Harmansole boring, 3 miles south of Canterbury, where the deposit is reduced to 2 feet of sandy clay full of phosphatic fragments.

Hythe Beds. In East Kent the Hythe Beds consist of alternating layers, generally about 6 inches to 2 feet thick, of hard, sandy, grey or blue-grey limestone ('ragstone') and grey-green loamy sand speckled with grains of glauconite ('hassock'). The beds rise from the shore at Mill

Point, Folkestone, and strike inland to form an escarpment overlooking Romney Marsh. Estimates of 60 feet for the thickness of the Hythe Beds at Hythe (e.g. Drew 1864, p. 7) are excessive; they attain a thickness of 50 feet at the edge of the escarpment at the western end of the region and diminish in thickness to the north and east. Thirty-five feet appears to be the maximum in the Hythe district, but locally the beds are much thinner, as at Repton Manor, three-quarters of a mile north-west of the centre of Ashford, where Worssam (in Worrall 1954) records only 15 feet. Borings show that the Hythe Beds become rapidly thinner and disappear altogether a short distance north of the outcrop. This was seen very clearly in the Brabourne boring, where the Hythe Beds were found to have vanished completely 2 miles north of where they make a brave show at the surface. The Dover Colliery shafts and borings farther north show that the Hythe Beds have a more restricted distribution than has the underlying Atherfield Clay and that they are overstepped by the Sandgate Beds.

The idea that the disappearance of the Hythe Beds north of their outcrop is due to facies-change or to post-depositional changes in character and that the 'rag and hassock' beds pass into a Sandgate Beds type of lithology underground has lately been revived by Worrall (1956). This author claims that the ragstone bands of the Hythe Beds outcrop originated fairly recently, after removal of the impervious Gault cover, and are the result of leaching of calcium carbonate from higher members of the Lower Greensand and its subsequent precipitation in the Hythe Beds. The petrographical evidence for this hypothesis seems to rest largely on the presence of a single blue tourmaline in the Sandgate Beds of the St. Margaret's Bay boring. In this boring the Sandgate Beds are no more than 40 feet in thickness and they yielded near their base a distinctive little lamellibranch (*Freiastarte praetypica* sp. nov.) (GSM Bm 5165–6) that characterizes the Sandgate Beds and basal part of the Folkestone Beds of East Kent. It has never been found elsewhere and its occurrence here thus supports the assumption that the strata in question are of Sandgate Beds age. There are, however, more cogent reasons for rejecting this hypothesis of secondary origin of the ragstone. Attention may be drawn to the fact that fossils in the ragstone are always 'solid' or only slightly distorted, whereas in the hassock all but the stout calcite belemnites and *Exogyra* are crushed flat. This means that originally the Hythe Beds were composed mostly of hassock and that the consolidation of the ragstone must have taken place before vertical pressure was exerted—certainly long before removal of the Chalk dome and the Gault had exposed the Lower Greensand to meteoric water. That such exposure has now resulted in partial *decalcification* of the ragstone is shown by the prevalence of fossil 'cast-beds' in the Hythe Beds. The presence of ragstone as pebbles and rafts in the basement-bed of the Sandgate Beds at Mill Point, Folkestone, is conclusively in favour of its primary origin.

The Hythe Beds carry a rich fauna belonging to the *deshayesi* and *bowerbanki* Zones of the Lower Aptian. Fossils are locally abundant; some species, such as the trigoniid *Linotrigonia* (*Oistotrigonia*) *ornata*, the oyster *Exogyra latissima*, and the brachiopods *Sellithyris sella* and *Sulcirhynchia hythensis* tend to occur in bands or nests. Other common fossils are—Lamellibranchia: *Sphaera corrugata*, *Venilicardia inornata*, *Pseudaphrodina ricordeana*, *Resatrix hythensis*, *Trigonia carinata*, *Pterotrigonia mantelli anterior*, *Yaadia nodosa*, *Gervillella sublanceolata*, *Gervillaria alaeformis*, *Plicatula placunea*, *Pinna* (*Stegoconcha*) cf. *gervaisei*. Gastropoda: *Conotomaria gigantea*. Cephalopoda: *Australiceras gigas*, *Tropaeum hillsi*, *T. bowerbanki*, *Cheloniceras cornuelianum*, *Ch. crassum*, *Dufrenoyia furcata*, *Cymatoceras radiatum*, *C. pseudoelegans*, *Eucymatoceras plicatum*, *Neohibolites ewaldi*. Brachiopoda: *Oblongarcula oblonga*. Echinoidea: *Holaster benstedi*, *Discoidea decorata*, *Tetragramma malbosi*. Polyzoa: *Chisma furcillata*, *Reptomulticava fungiformis*. Foraminifera, radiolaria, and ostracoda are found in some of the beds but have not been studied. A series of enormous limb and pelvic bones, collected by H. B. Mackeson (1840) from the Hythe Beds of Hythe and thought to belong to the marine reptile *Polyptychodon*, were later diagnosed by Owen (1884) as belonging to a new genus and species of dinosaur, *Dinodocus mackesoni*. Besides *Conotomaria*, the beds yield other exceptionally large gastropods, such as the limpets *Hipponyx neocomiensis* and *Brunonia* *gigantea* (Gardner 1877*a*; 1877*b*), the last being 4 inches in diameter. The quarrymen have their own names for some of the fossils: internal moulds of *Sphaera corrugata* are called



TEXT-FIG. 4. Graphic section of the Hythe Beds, Otterpool Quarry, near Hythe, Kent.

'bullocks' hearts' and detached shafts of the uncoiled ammonoids *Australiceras* and *Tropaeum* are known as 'hosepipes': ammonites and nautiloids are 'whirligigs' and the large *Conotomaria* 'screws'.

The old Hythe quarries, worked for building stone, are now defunct but there are good

Section exposed in Otterpool Quarry, June 1955

	ft.	*in.*
Sandgate Beds		
34. Brown-weathered glauconitic loam, passing up into soil	2	0
33. Band of small white phosphatic nodules		2–6
Hythe Beds		
32. Dark-green calcareous hassock with doggers of green calcareous sandstone and grey sandy limestone	2	3
31. Dark-green indurated hassock, well laminated and weathering grey; crowded with fossils (*Linotrigonia, Gervillella, Exogrya*, &c.; *Ch. meyendorffi* group)	4	9
30. Grey-green calcareous sandstone with scattered small black phosphatic nodules; *Exogyra* bed at top	1	3
29. Grey hassock with doggers of ragstone (*Ch. meyendorffi, Dufrenoyia*)		6
28. Brown ragstone with weathered-out shells		8
27. Grey hassock		2–4
26. Brown, blue-hearted ragstone		9
25. Grey hassock		8
24. Ragstone as 26 (*Tropaeum bowerbanki, Dufrenoyia furcata, D. lurensis, Ch. cornuelianum*)	1	0
23. Grey hassock	1	0
22. Massive brown, blue-hearted ragstone, split by hassock veins into three equal lanes; very fossiliferous, the fossils in the top lane ('Green bed') having a green-dappled surface. Fauna as in 24	3	0
21. Hassock parting		3
20. Ragstone as 26, with impersistent cast bed at top (*Tropaeum bowerbanki*)	1	4
19. Grey hassock		6
18. Ragstone as 26, with impersistent cast bed at top and nests of *Sellithyris sella* and *Sulcirhynchia hythensis*. (*Ch. cornuelianum, Ch. crassum, Dufrenoyia furcata, D. transitoria*)	1	6
17. Hassock parting		2
16. Ragstone as 26	1	0
15. Hassock parting		3
14. Ragstone as 26 (*Dufrenoyia furcata, D. truncata*)	1	0
13. Grey hassock		6
12. Ragstone as 26, locally forming a cast bed (*Ch. cornuelianum, Ch. crassum*)		9
11. Grey hassock		6
10. Ragstone as 26		6–9
9. Hassock parting		2
8. Massive pale blue-grey ragstone, glauconitic (*Tropaeum hillsi*)	1	6
7. Grey-green hassock		6–11
6. Ragstone as 8 (*Australiceras gigas*)	1	9
5. Grey-green hassock	1	3
4. Ragstone as 8		9
3. Rubbly bed of blue-grey ragstone nodules in blue-green hassock	1	0
2. Ragstone as 8 (*Ch. parinodum, Deshayesites* cf. *involutus*); numerous large *Exogyra* on upper surface	1	6
1. Blue-green sandy clay . . . seen (passing down into Atherfield Clay according to description supplied by quarry manager)		6
Total of Hythe Beds about	35 feet	

exposures inland where the ragstone is extracted for road metal. The best is at Otterpool Manor (Folkestone Quarries, Ltd.), just south of the main Folkestone–Ashford road, a mile west of New Inn Green cross-roads and about 3 miles north-west of Hythe. The whole of this division and its junction with the Sandgate Beds are here seen in the quarry faces, as detailed on p. 522 and illustrated in text-fig. 4. This section may be taken as a standard for East Kent.

The blue-grey, glauconitic basal 9 feet of this section belong to the *deshayesi* Zone, the presence of the *parinodum* Subzone being indicated by *Ch. parinodum* and *Deshayesites* cf. *involutus* in bed 2, and of the *grandis* Subzone by *Tropaeum hillsi* in bed 8. The remaining 26 feet of strata (beds 9–32) are assigned to the *bowerbanki* Zone and yield abundant faunal evidence of both its subzones, the *transitoria* Subzone below, the *meyendorffi* Subzone above. The *meyendorffi* Subzone (beds 29–32) carries little ragstone, the beds consisting mainly of green hassock, in places hardened to sandstone, with numerous guards of the belemnite *Neohibolites ewaldi*. An *Exogyra* bed (bed 30) with small phosphatic nodules lies near the base.

The blue-grey ragstones of the *deshayesi* Zone, resting on blue-green sandy clay, are well exposed in quarries on either side of the main Folkestone–Ashford road, half a mile south-west of Willesborough, near Ashford. Here they have yielded the diagnostic fossils, *Ch. parinodum* and *Deshayesites* of the *involutus* and *grandis* groups in the bottom two lanes of ragstone, with *Australiceras gigas*, *Lithancylus grandis*, and *Cheloniceras cornuelianum* in a 'cast-bed' about 8 feet above the quarry floors. The same fauna has been collected from shallow workings at Merstham and from the Handen Quarry, Clap Hill, Aldington, associated at the latter locality with *Tropaeum hillsi*. From the basal few feet of the Hythe Beds in the railway cutting half a mile west-north-west of Smeeth Station officers of the Geological Survey collected a small fauna which included the ammonites *Ch.* aff. *parinodum*, *Deshayesites deshayesi*, *D. multicostatus*, and *D. consobrinoides*.

A shallow working at Shepway Cross, Lympne, 2 miles west of Hythe, exposes 12 feet of rag and hassock of the lower part of the *bowerbanki* Zone and the top of the *deshayesi* Zone. Several feet of bright green glauconitic sandstone and hassock, with crushed *Cheloniceras* of the *meyendorffi* type, were seen to underlie the Sandgate Beds in road-building operations at the top of Bartholomew's Lane, Hythe, and the same beds, with an underlying phosphatic nodule-bed, may just be made out in the old quarry-site at Tanner's Hill, on the east side of Hythe. The eastward continuation of these green hassocky beds of the *meyendorffi* Subzone cannot be followed. The site of Jeal's Quarry, just north of the sluice gate at Seabrook, a mile to the east, is now occupied by private gardens, and the old Horn Street Quarry, about half a mile north of Jeal's, is completely overgrown. Judging by the Old Series map both lie close to the junction with the Sandgate Beds, but the only ammonites preserved from these quarries are of *transitoria* age. On the shore at Mill Point, Folkestone, another 2 miles to the east, there is no sign of the *meyendorffi* Subzone, the top of the Hythe Beds consisting of brown ragstone with an ammonite fauna similar to that of the top of the *transitoria* Subzone at Otterpool. Its destruction prior to the next phase of deposition is shown by bits of greenish sandstone, ragstone, and rolled phosphatic fossils in the basement-bed of the Sandgate Beds (see below).

Sandgate Beds. In East Kent the Sandgate Beds are composed of greenish, grey, and slate-coloured loams and dark-grey silty clay. Exposures are poor and estimates of the thickness of the beds vary considerably. Worrall (1954, p. 192) believes they reach as much as 120 feet at Sellindge, but only 30 feet at Hinxhill. Seventy to eighty feet seems a reasonable figure for their thickness in the Folkestone area. The Sandgate Beds are transgressive and everywhere in East Kent their base is marked by a band of phosphatic nodules or by other signs of a pause or break in sedimentation. In the Dover Colliery shafts and in the St. Margaret's Bay boring they were found to have overstepped the Hythe Beds and to rest on the bored top of the

Atherfield Clay. Farther north, at Walmestone and Ebbsfleet, borings show them in contact with the Weald Clay.

At Folkestone, Price (1874) divided the Sandgate Beds into four beds, as follows:

4. Yellowish green sands, passing into brownish clayey sands upwards.
3. Black clayey sands, in part resembling the Gault.
2. Dark-green sands, passing up into yellowish-green sands.
1. Zone of *Rhynchonella sulcata*. Black sands with nodules of iron pyrites.

This section was compiled from exposures in the Lower Sandgate road and on the foreshore east of Folkestone Harbour. No thicknesses were given for the individual beds and for reasons stated below it is believed that the section is very incomplete and unreliable. The principal error is in the position of the 'Zone of *Rhynchonella sulcata*', which lies not at the base of the Sandgate Beds but near the top. This bed was formerly exposed at low-water spring tides east of the Harbour but is now buried beneath modern shore deposits. Topley (1875), following De Rance (1868), took it for the base of the Folkestone Beds, but on the advice of Price transferred it to the Sandgate Beds (Topley 1875, p. 138, footnote). The real base of the Sandgate Beds crops out between tide marks on the shore at Mill Point, a mile south-west of Folkestone Harbour, and the north-easterly dip of the strata makes it impossible for it to appear again at low water east of the Harbour.

Museum collections testify to the fossiliferous nature of the 'Zone of *Rhynchonella sulcata*', which is characterized chiefly by the lamellibranchs *Resatrix* (*Dosiniopsella*) *cantiana*, *Eriphyla striata*, *Freiastarte praetypica* sp. nov., *Anthonya cantiana*, *Cucullaea glabra*, *Parmicorbula striatula*, *Lucina cornueliana*, *Gervillella sublanceolata*, *Yaadia nodosa*, *Pterotrigonia mantelli*, and an abundance of *Lamellirhynchia caseyi* (= *Rhynchonella sulcata* Auctt.). Bones of *Ichthyosaurus campylodon* and the chimaeroid fish *Edaphodon* also occur. This is the type horizon of *Anthonya cantiana*, credited by Woods (1906, p. 130) to the Folkestone Beds.

About 1,000 yards south-west of the Harbour the top part of the Sandgate Beds may be seen in bare patches on the bank above the promenade. It consists of a few feet of pale yellow-green, micaceous, and silty sand, passing down into dark-grey, micaceous, and more clayey sand. Excavations made in 1956 in the adjoining gardens of the Lower Sandgate Road, 120 yards west of the site of the Victoria Pier, passed through these same beds and entered a dark-green clayey sand with fossiliferous concretions, presumably the 'Zone of *Rhynchonella sulcata*'. In addition to poorly preserved lamellibranchia and *Lamellirhynchia*, material thrown out of the trenches included the ammonites *Nolaniceras* aff. *nolani* and *Nolaniceras* sp. juv. These are probably the '*Ammonites deshayesi*' recorded from this horizon by Topley (1875, p. 139) and are of great interest as establishing the presence of the *nolani* Subzone in the Sandgate Beds.

Bare patches in the undercliff and gardens of the Lower Sandgate Road afford glimpses of green and slate-coloured loams, but the prevalence of landslipping in the area makes it hazardous to connect the exposures into a vertical succession. From 200 to 50 yards west of Mill Point the top of the Hythe Beds appears at low water as a seaweed-covered reef and its junction with the Sandgate Beds is sometimes seen after storms have scoured the beach. The section given on p. 525 was seen in the summer of 1957, when the foreshore had been cleared of shingle to an extent unprecedented in living memory.

The boxstones of bed 1 formed a red cobbled pavement on the broken ledges of Hythe Beds exposed by the receding tide. This extraordinary bed has a complex history and it incorporates three distinct elements: (1) debris from the destruction of the *meyendorffi* Subzone at the top of the Hythe Beds (sandstone and ragstone pebbles and black nodules, much rolled), (2) buff-grey phosphatic nodules of *buxtorfi* age, perhaps contemporaneous with the grey calcareous inclusions, and (3) an indigenous fauna of lamellibranchs and brachiopods of *nutfieldensis* age. *Cheloniceras* (*Epicheloniceras*) *buxtorfi*, here found in buff-grey phosphate, is an important zonal ammonite, not previously known in Britain. It characterizes the nodule-bed of Luitere Zug, in the Engelberger Valley, Switzerland, and was used by Jacob (1907) as an index-fossil for the upper part of the Gargasian (his subzone IIb). The indigenous fauna is chiefly remarkable for its large brachiopods, *Cyrtothyris cyrta*, *C. uniplicata*, and *Cyclothyris latissima*, found together elsewhere only in the Faringdon Sponge Gravels. Lamellibranchs are plentiful, the commoner forms being: *Arca dupiniana*, *Limopsis dolomitica* sp. nov., *Entolium orbiculare*,

Section of Sandgate Beds exposed at low water at Mill Point, Folkestone, August 1957

		ft.	*in.*
6. Dark-green glauconitic clayey sands	seen	1	0
5. Large concretionary masses of olive-green, brown-weathering calcareous sandstone, with intertwined cylindrical bodies like stems of plants on the outside; each has a large brown phosphatic nodule (up to 12 in.) in the centre, surrounded by bright green glauconitic clayey sand. Fossil wood		2	0
4. Very dark (almost black) sandy glauconitic clay, full of burrows infilled with sandier material, some apple-green in colour. Pyrites crystals at top. *Exogyra latissima*		2	0
(Concealed; estimated gap 10 ft.)			
3. Very dark glauconitic loam with hard doggers	seen	1	9
2. Pebble-bed; mainly black cherts up to ½ in. in matrix of glauconitic loam with brown, green, and mustard-coloured streaks			2–4
1. 'Conglomeratic' bed, composed of boxstones impressed into the top of the Hythe Beds. Each boxstone has a mammillated ironstone rind, brick-red in colour, which encloses rounded lumps of hard grey-green gritty calcareous rock, dolomitic in places; small pebbles occur both inside the boxstones and in the rind, mainly in clusters; some of the pebbles are rolled pieces of bone and teeth of fish; black phosphatic nodules (including rolled moulds of lamellibranchs) scattered throughout; pieces of grey ragstone, greenish calcareous sandstone, buff-grey phosphatic nodules and pale-grey calcareous inclusions also occur in the boxstones. Eastwards the boxstones become larger and flatter and hold a more sandy and shelly content. A single large raft of ragstone, 4 in. thick, noted			4–9
Hythe Beds. Light-brown fossiliferous ragstone with carious upper surface			5–9
Total about		8	0

Chlamys robinaldina, *Acesta longa*, *Thetironia minor*, *Pseudocardia sp. nov.*, *Proveniella regularis*, *Exogyra tuberculifera*, *Gryphaeostrea canaliculata*. A few specimens of *Myopholas* cf. *semicostata* were found in position of life, apparently bored into the top of the Hythe Beds. In the Dover sinkings, between depths of 300 and 388 feet, the Sandgate Beds were found to have a fauna similar to that of the 'Zone of *Rhynchonella sulcata*', with *Lamellirhynchia caseyi*, *Resatrix* (*Dosiniopsella*) *cantiana*, *Parmicorbula striatula*, &c., and with the boring shells *Girardotia* and *Panopea* descending into the underlying Atherfield Clay (Lamplugh and Kitchin 1911; fossil-names revised).

The stone doggers in bed 3 were recognized as the source of the *Parahoplites nutfieldensis* recorded from the base of the Sandgate Beds at this spot (Casey 1939, p. 368).

Drew (1864, p. 9) described the basement-bed of the Sandgate Beds at Mill Point ('shore near the turnpike between Sandgate and Folkestone') as a ferruginous layer 6 inches thick and the same description was applied to the bed once exposed in the Horn Street Quarry, Seabrook ('hill side between Hythe and Shorncliffe' in Topley 1875, p. 129). It now appears doubtful whether these old records can be used as evidence of discontinuity of the nodule-bed (e.g. Worrall 1954, p. 191). Rather it would seem that the nodules are made less conspicuous by secondary formation of ironstone. They were found to be present at the junction with the Hythe Beds in the Otterpool Quarry, described above, and were very clearly exposed in a temporary road-cutting 100–200 yards south of Grove Bridge, Sellindge, where the following section was measured in June 1953:

Section of Hythe–Sandgate Beds junction near Grove Bridge

	ft.	in.
Sandgate Beds		
5. Dark-green glauconitic loam with a line of incipient phosphatic nodules 18 in. above base . . . . seen	4	6
4. Phosphatic nodule band. Compact glauconitic loam crowded with whitish phosphatic nodules (seldom more than 1 in. long); many of the nodules are internal moulds of mollusca; some are incompletely phosphatized 6 in. to	1	3
Hythe Beds		
3. Bright green glauconitic hassock with two lines of indurated doggers, the lower with a concentration of small *Exogyra* at top, the upper with an impersistent reddish-brown coat . . . . . . 2 ft. 6 in. to	3	0
2. Brown, blue-hearted ragstone	1	6
1. Grey-green glauconitic hassock	2	0
Total about	12	0

The phosphatic nodule band (bed 4) was rich in fossils, lamellibranchia predominating, with the venerids *Pseudaphrodina ricordeana* and *Resatrix hythensis* especially common. The brachiopods *Sellithyris sella* var., *Sulcirhynchia hythensis*, *Praelongithyris praelongiforma*, and *Oblongarcula oblonga* were present and rare specimens of *Cheloniceras* (*E.*) *buxtorfi* and *Ch.* (*E.*) *sp. nov.*, the whole assemblage suggesting a condensed deposit equivalent to the upper part of the Hythe Beds (*martinioides* Zone) of the Maidstone area. A similar phosphatized fauna at the base of the Sandgate Beds in the neighbourhood of Great Chart, near Ashford, has been described by Topley (1875, p. 129), Gregory (1895), and Kirkaldy (1937). Unfortunately, the only ammonite recorded from here (as *Cheloniceras* cf. *cornuelianum*) is too immature to be identified closer than *Cheloniceras sensu lato*.

It is thus seen that the Sandgate Beds of East Kent span the *martinioides*, *nutfieldensis*, and basal part of the *jacobi* Zone of the Upper Aptian, the first zone being represented in highly condensed form in the basal nodule-bed.

Folkestone Beds. Within the East Kent region the Folkestone Beds undergo marked changes in thickness and lithology. In the cliffs east of Folkestone Harbour they consist of about 60 feet of coarse yellowish greensands with bands of calcareous and glauconitic sandstone. Westwards they pass into uncompacted sands, more or less ironstained, current-bedded, and generally devoid of organic content. One hundred and eleven feet of such sands were encountered in the Brabourne boring. In the Kent Coalfield area, under cover of the Gault, they are reduced to a few feet of calcareous and glauconitic grit, resembling in condensed form the beds as seen at Folkestone.

The zonal stratigraphy of the Folkestone Beds in the type region may be summarized as follows (Casey 1939; 1950): in the coast section the beds belong mostly to the *regularis* Subzone, the topmost part of the *tardefurcata* Zone, with a few feet of *mammillatum* Zone at the top. Underlying the *regularis* Subzone is a remnant of the middle third of the *tardefurcata* Zone (*milletioides* Subzone) and this in turn rests non-sequentially on a condensed basement-bed of middle and upper *jacobi* age. Traced westwards the *jacobi* and *milletioides* deposits expand rapidly. Complementary to this expansion of the bottom beds, the *regularis* and lower *mammillatum* strata wedge out beneath the transgressive top of the *mammillatum* Zone (*puzosianus* Subzone) and disappear less than 5 miles inland from Folkestone. At Sellindge, near Brabourne, 8½ miles from the coast, the whole division has passed into sands of *jacobi* age, capped by the nodule-beds of the *puzosianus* Subzone.

At East Cliff, Folkestone, the beds are admirably displayed in contact with the Gault for a distance of half a mile. Due to the north-easterly dip they decline gently to the shore and are lost beneath the tide-mark in East Wear Bay, just beyond Copt Point. Measured sections of the cliff were given by Fitton (1836) and Hinde (1885), but these do not seem to fit any part of the succession exposed today. Price (1874) gave a fuller description of the beds and divided them into four and the present author gave these divisions zonal definition (Casey 1939; 1950).

The section on p. 528 was measured in 1939 at Baker's Gap, East Cliff, about 30 yards short of the eastern extremity of the present promenade.

The lowest 10 feet of the succession, obscured for many years, was made accessible in 1937–9 during the construction of a promenade at East Cliff. Reference has already been made to the extraordinary composition of the basement-bed (Price's bed 1) and the important palaeontological information obtained from it in the course of these operations (Casey 1939; 1950), but since the bed is now permanently concealed by the promenade it is desirable to place on record the fullest particulars of its occurrence. A representative set of specimens is lodged at the Geological Survey.

The work of clearance and excavation along the foot of the cliff provided a continuous section of nearly 200 yards in which it was possible to examine the basement-bed. Previous authors have described it as a brown ferruginous sandstone: in the unweathered state it was found to consist chiefly of a firm glauconitic sand, somewhat loamy in places and not always sharply separable from the underlying silty greensands of the Sandgate Beds. Here and there it contained pockets of a buff siliceous rock, almost devoid of glauconite and argillaceous matter but highly charged with shell-debris, sponge-spicules, and minute echinoid-radioles. The bed held an abundance of black phosphatic nodules and was sprinkled liberally with white and green-veined quartz, black chert, and green sandstone in well-rounded and subangular fragments up to an inch in length. The pebbles also included oval, flat-sided pieces of a soft green stone, sometimes showing bedding—perhaps a brecciated glauconitic mud. Dark-brown concretions of ferrugino-phosphatic rock, mostly spherical in shape and averaging 6 to 8 inches diameter, were of more sparing occurrence. Phosphatic nodules and concretions were all thickly coated with oysters, polyzoa, and other encrusting bodies. The nodules were mostly shapeless lumps of calcium-phosphate-cemented sand, but some took the form of hollow cylindrical structures with encrusting organisms both inside and outside; others were the rolled remains of crustaceans, ammonite body-chambers, logs of wood, or aggregates of fossil shells. Especially interesting were some large nodules riddled with ramifying perforations, where arborescent polyzoa, since rotted away, had formed the nucleus of growth of the nodules. Fish teeth and bone-fragments of larger vertebrates were also found in a phosphatized condition. Internal cavities in the nodules due to the disappearance of shelly material were often lined with a film of tarnished pyrites. The ferrugino-phosphatic concretions were highly fossiliferous, though many contained nothing but a small species of *Parmicorbula*, so densely packed that the external moulds of the shell gave the rock a peculiar scoriaceous appearance. In the most westerly part of the section, nearest the Harbour, these concretions occupied the lowest part of the basement-bed, as described by Price, but farther east they were concentrated together with the black nodules in the middle of the bed. In the most easterly excavation that touched the Sandgate Beds no concretions were seen, but from the very bottom of the basement-bed

Section of Folkestone Beds at Baker's Gap, East Cliff, Folkestone

		ft.	in.
mammillatum Zone			
35. 'Sulphur Band'. An indurated layer of phosphatic nodules, the nodules veined and encrusted with pyrites and embedded in a matrix of clayey greensand, the whole coloured yellow and reddish-brown by decomposition products. Two distinct concentrations of nodules recognizable. Abundant fossil wood	1 ft. to	1	3
34. Coarse grey sand, somewhat clayey at top	1 ft. 6 in. to	2	0
33. Main *mammillatum* Bed. Seam of coarse yellow-green sand and grit with clusters of phosphatic nodules	6 in. to	1	0
32. Very coarse yellowish sand and grit	1 ft. to	1	6
31. Incoherent yellowish greensand		3	0
30. Hummocky band of indurated sand and grit with pockets of small pebbles weathered out as knobs on the upper surface		1	3
29. Very coarse yellowish sand and grit with small pebbles and shell fragments		2	2
28. *Sonneratia kitchini* Bed. Line of small black phosphatic nodules scattered irregularly through coarse yellowish sand. Wisps of grey clay	4 in. to		8
tardefurcata Zone			
27. Very coarse sand and grit as 32		2	2
26. Hummocky band of indurated calcareous grit		1	2
25. Yellowish greensand with small ferruginous nodules scattered and in lines		10	0
24. Band of carious spicular sandstone, porcellanous and cherty in places			9
23. Yellowish greensand with lenticles of sandstone as above. Comminuted lamellibranch shells		1	2
22. Yellowish greensand		3	9
21. Sandstone as 24	6 in. to		10
20. Yellowish greensand		1	2
19. Impersistent sandstone as 24			0–5
18. Yellowish greensand		2	5
17. Tough grey calcareous sandstone		1	4
16. Yellowish greensand			11
15. Impersistent sandstone as 24			0–3
14. Yellowish greensand		3	0
13. Hummocky tough grey calcareous sandstone	9 in. to	1	0
12. Sandstone as 24	9 in. to	1	0
11. Yellow-green, slightly clayey sand with patches and wisps of iron-staining		4	4
10. Impersistent sandstone as 24			0–3
9. Sand as 11. Obscured by talus	estimated	7	0
8. Sandstone as 24			6
7. Greenish loamy sand, weathering brown		1	3
6. Bright-green loamy sand		1	4
5. Pockets of small phosphatic nodules and pebbles of black chert. Large *Exogyra* numerous			0–2
4. Tough grey-green, glauconitic, calcareous sandstone band		1	9
3. Nodular bed as 5			0–2
2. Well-compacted clayey greensand with abundant shell fragments and very small pebbles of black chert		2	0
jacobi Zone			
1. Firm glauconitic loamy sand, weathering brown, holding a great quantity of pebbles and black phosphatic nodules, with large spherical concretions of ferrugino-phosphatic rock at the base. Encrusting oysters common		1	0
Sandgate Beds. Yellow-green silty sand			
Total of Folkestone Beds about		60	0

the picks of the labourers uncovered lenticular masses (a few inches in thickness) of ferruginous stone. The lenticles had an ironstone core without granular structure and graded outwards into a sepia-coloured sandstone with pellets of apple-green clay, clusters of small quartz and chert pebbles, and shell debris, all converted into a hard, gritty mass. Black phosphatic nodules studded the skins of the lenticles, which were oxidized to a brick-red colour.

Some of the commoner fossils found in the ferrugino-phosphatic (*rubricosus*) concretions are the lamellibranchs *Parmicorbula striatula*, *Resatrix* (*Dosiniopsella*) *cantiana*, *Freiastarte praetypica*, *Pterotrigonia mantelli*, *Thetironia minor*, the gastropod *Margarites* (*Atira*) *mirabilis*, the ammonites *Hypacanthoplites rubricosus*, *Id.* var. *tenuiformis*, *Id.* var. *papillosus* and *H.* aff. *jacobi*, and the lobster *Homarus longimanus*. Nests of *Lamellirhynchia caseyi* are also found in this type of preservation. The black (*anglicus*) nodules yielded chiefly *Thetironia minor*, *Cucullaea glabra*, and *Tortarctica similis*, together with *Homarus longimanus* and the following ammonites: *Hypacanthoplites jacobi*, *H. anglicus*, *Id.* var. *audax*, *H. clavatus*, *H. elegans*, *H.* cf. *sarasini*, *H.* cf. *hanovrensis*, *H. simmsi*, *H.* cf. *spathi*, *H.* cf. *laticostatus*, *H. spp. nov*. The ferruginous stone contained *Epicyprina harrisoni*, *Tortarctica similis*, *Spondylus striatus*, *Resatrix* (*Dosiniopsella*) *cantiana*, *Acesta longa*, and indeterminate vertebrate remains. Bones of *Ichthyosaurus campylodon* and teeth of *Isurus mantelli* occurred loose in the sand. *Lopha diluviana*, *Ostrea cunabula*, *Diploschiza sp.*, and the polyzoans *Proboscina crassa* and *Berenicea gracilis* had later used the nodules and bones for anchorage.

This basement-bed speaks of long exposure on a sea-floor free of sedimentation. During this standstill in deposition at Folkestone the basal *tardefurcata* Zone (*farnhamensis* Subzone) was laid down elsewhere.

The succeeding 2 feet of glauconitic clayey sand (Price's bed 2) is without ammonites but contains much shelly debris and the following identifiable forms: *Oxytoma pectinatum*, *Lopha diluviana*, *Entolium orbiculare*, *Neithea quinquecostata*, *Serpula articulata*. This bed is assigned to the middle third of the *tardefurcata* Zone (*milletioides* Subzone) because its westwards continuation (at Newington) contains *Hypacanthoplites* of the *milletioides* type.

Price's third division of the Folkestone Beds commences with a band of calcareous glauconitic sandstone with clusters of small pebbles, phosphatic nodules, and *Exogyra* strung along the top and bottom. *Leymeriella regularis*, *L. pseudoregularis*, *Anadesmoceras sp.*, and a giant undescribed *Douvilleiceras* are found either in the nodules or in the sandstone itself. The little pteriid *Oxytoma pectinatum* is plentiful here. Though replete with fossils of other groups, the succeeding 50 feet of sands and rock bands are very poor in ammonites. They have yielded fragments of large *Douvilleiceras* and the single example of *L. regularis* recorded by Spath (1933). This part of the succession contains seams of whitish, sinter-like 'sponge-rock'—largely aggregates of sand-grains and sponge-spicules bound together by a calcareous matrix. Their weathered surfaces provide some of the best fossil-collecting in the Folkestone Beds: *Exogyra latissima*, *Lopha diluviana*, *Entolium orbiculare*, *Aptolinter aptiensis*, *Tortarctica similis*, *Cucullaea glabra*, *Pterotrigonia mantelli*, *Inoceramus coptensis*, the echinoids *Holaster* (*Labrotaxis*) *cantianus* and *Phyllobrisus artesianus*, the annelid *Serpula articulata*, the brachiopod '*Rhynchonella*' *gibbsiana*, and the polyzoan *Siphodictyum gracile* are of fairly common occurrence. Despite the myriads of spicules present in the rock, recognizable sponges do not occur. Branching and intertwining cylindrical bodies commonly seen on the surfaces of the stone doggers, thought by early writers to be some sort of sponge, are probably infilled lamellibranch burrows. *Exogyra* shells are commonly infested with the tubular stolons and vesicules of the boring polyzoan *Graysonia*. The types of the starfish *Lophidiaster ornatus* and the curious jointed worm-tube *Serpula articulata* were both obtained from here and wrongly attributed to the Upper Greensand.

The *mammillatum* Zone begins with the *Sonneratia kitchini* bed, a line of small phosphatic nodules in clusters, 10 feet below the base of the Gault, with bits of *Sonneratia* and *Douvil-*

leiceras mammillatum. The main bed of *D. mammillatum* is in the topmost 6 feet of sand (Price's fourth division), the fossils occurring in a band of nodules up to a foot in thickness and from 1½ to 4 feet below the top of the sand. Collecting is best done among the weed-covered reefs and rocky pools east of Copt Point after the bed has been washed over by the sea. *Inoceramus salomoni*, *Panopea gurgitis* var. *plicata*, *Nanonavis carinata*, *Cucullaea glabra*, *Thetironia minor*, *Resatrix* (*Dosiniopsella*) *vibrayeana*, *Pseudocardia tenuicosta* var. *constanti*, *Pterotrigonia mantelli*, *Linotrigonia fittoni*, *Entolium orbiculare*, *Neithea quinquecostata*, *Exogyra latissima*, and *Gryphaeostrea canaliculata* are the lamellibranchs most frequently met with and *Anchura* (*Perissoptera*) *parkinsoni*, *Tessarolax retusum*, *Eucyclus sp. nov.*, *Metacerithium trimonile*, *Mesalia* (*Bathraspira*) *tecta*, *Leptomaria gibbsi*, and *Gyrodes genti* are the chief gastropods. The nautiloid *Eutrephoceras clementinum* is not uncommon, but belemnites are exceedingly rare. Ninety-five per cent. of the ammonites are species of *Douvilleiceras* and *Beudanticeras*, usually in pieces, but the minority fauna is of great diversity, as the following list shows: *Douvilleiceras mammillatum*, *D. monile*, *D. orbignyi*, *D. spp. nov.*, *Beudanticeras newtoni*, *B. dupinianum*, *Uhligella subornata*, *Parengonoceras ebrayi*, *Hypacanthoplites* cf. *milletianus*, *Otohoplites raulinianus*, *O. elegans*, *O. auritiformis*, *O. guersanti*, *O. spp. nov.*, *Protohoplites* (*P.*) *latisulcatus*, *P.* (*Hemisonneratia*) *sp.*, *Sonneratia dutempleana*, *S.* aff. *parenti*, *Pseudosonneratia spp. nov.*, *Cleoniceras* (*C.*) cf. *cleon*, *C.* (*C.*) *floridum* sp. nov., *C.* (*C.*) *janneli*, *C.* (*C.*) *seunesi*, *C.* (*C.*) *quercifolium*, *C.* (*C.*) *spp. nov.*, *C.* (*Neosaynella*) *inornatum*, *C.* (*N.*) *sp. nov.*, *Tegoceras sp. nov.*, *Oxytropidoceras alticarinatum*, *Hamites praegibbosus*, *H. spp. nov.*, *Protanisoceras raulinianum*, *P. cantianum*, *P. lardyi*, *P. blancheti*, *P. acteon*, *P. vaucherianum*, *P.* cf. *halleri*, *P. spp. nov.*, '*Prohelicoceras*' *anglicum*, Gen. nov. ('*Metahamites*') sp. nov. Crustacea, polyzoa, and echinoidea are rare. There are isolated finds of teeth or bones of the shark *Isurus mantelli* and the marine reptiles *Polyptychodon* and *Ichthyosaurus* and I have also collected a vertebra of the dinosaur *Acanthopholis horridus* (GSM Zk 4775). A big reptilian fauna is known at this horizon in the Ardennes.

The nodules, with their black and brown phosphatic fossils, are the remanié in place of the *floridum* and *raulinianus* Subzones. *Protohoplites*, *Sonneratia dutempleana*, and *Otohoplites guersanti* occur only in the matrix of the nodules, unphosphatized or incompletely phosphatized and generally with their nacre. They are part of a later fauna belonging to the *puzosianus* Subzone; so too is the small zeilleriid *Modestella modesta*, which probably grew on the nodules.

The 'Sulphur Band', described previously (Mackie 1856, 1860; Casey 1950), still lies in the *puzosianus* Subzone, having yielded *Inoceramus salomoni*, fragments of *Protohoplites* and *Pseudosonneratia*, *Cleoniceras* cf. *quercifolium*, large indeterminate *Otohoplites*, and the long-ranging *D. mammillatum*, *D. monile*, and *B. newtoni*. Its washed residue contains sponge-spicules, including ribbed spicules of *Geodites*, and glauconitic pseudomorphs of foraminifera. Fossil wood bored by *Terebrimya*, *Martesia*, and *Xylophagella* is copious. Though generally taken as the commencing point of the Gault, this 'junction-bed' of the early authors is now put in

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EXPLANATION OF PLATE 78

Fig. 1. East Cliff, Folkestone, looking eastwards to Copt Point, low tide. Folkestone Beds overlain by Gault at their type locality.

Fig. 2. Copt Point, Folkestone. Junction of Folkestone Beds and Gault with waveworn blocks of Folkestone Beds (*regularis* Subzone and *mammillatum* Zone) on the shore. The 'Sulphur Band' may just be made out as a thin ledge at the junction.

Fig. 3. Sandpit at Brabourne Lees, East Kent. Pale, current-bedded sands of the *jacobi* Zone (*anglicus* Subzone) are overlain unconformably by glauconitic loams of the *mammillatum* Zone (*puzosianus* Subzone), the whole capped by flint-drift.

the Lower Greensand to avoid having a local formational boundary in the middle of a zone. The foot or two of dark sandy clay with phosphatic nodules underlying the 'Sulphur Band' in the Dover Colliery shafts is also of *puzosianus* age, as is denoted by the presence of *Protohoplites michelinianus*, var. (*Hoplites* cf. *raulinianus* in Lamplugh and Kitchin 1911, p. 100).

Westwards from East Cliff the basal beds of the Folkestone Beds (beds 1 and 2) expand rapidly. Black phosphatic nodules with the *anglicus*-fauna were seen in a bare patch of cliff near the bottom of Remembrance Road, about 300 yards west of the Harbour, but the *rubricosus* concretions were absent and the underlying sand was found to be still of Folkestone rather than Sandgate Beds type. Here was also observed the introduction of seams of siliceous stone in bed 2. The tough glauconitic sandstone ('bottom stone band') at the base of the *regularis* Subzone may be followed from this point through the undergrowth of the escarpment above the Lower Sandgate Road until it emerges in a clear section at Mill Point, just beyond the Toll Gate. Using the same enumeration for the beds as at East Cliff, we may summarize the section as follows:

Summarized section of Folkestone Beds at Mill Point, Folkestone

		ft.	*in.*
Beds 6–27.	Coarse yellowish greensand with seams of carious spicular sandstone and tough calcareous sandstone	55	0
4–5.	Tough, grey-green, glauconitic sandstone band, pebbly at top .	2	0
3.	Band of phosphatic nodules (up to 1 in. long)		6
2.	Compact green and brown loamy sand with bands and lenses of siliceous stone from 1 ft. to a few inches in thickness. Nests of very small lydite pebbles, phosphatic nodules, and shell debris, the phosphatic nodules commoner at the top, where they tend to lie in lines	16	0
1.	Brown sandy clay with small phosphatic nodules, pebbles, and rolled pieces of *Homarus*, the nodules concentrated in a band 1 ft. above base	3	0
	Sandgate Beds. Pale, almost white, silty sand		
	Total of Folkestone Beds	76	6

As at Remembrance Road, there is no sign of the *rubricosus* concretions in bed 1 and the only ammonites obtained from here are fragmentary *Hypacanthoplites* of the *anglicus* type, together with large body-chamber portions referable to the same genus. One of these was identified by Spath as *Parahoplites nutfieldensis* and recorded by me (Casey 1939, p. 368) under that name.

Road-widening in the 1920's in Upper Folkestone Road (Sandgate Hill), at the west end of Folkestone, exposed the bottom stone band of the *regularis* Subzone with several gigantic *Douvilleiceras* and *Leymeriella*, just as at East Cliff. The coarsely glauconitic stone (with an ammonite) encountered 66 feet below the Gault in a well at Folkestone Waterworks (Whitaker 1908, p. 139) is almost certainly the same band.

About a mile and a quarter west of Mill Point, in the grounds of Encombe, Sandgate, the basement-bed of the Folkestone Beds is seen to have expanded into several feet of loose sand with a line of ferruginous nodules. Pieces of these nodules, with lamellibranchia and *Hypacanthoplites*, may be picked up on the beach at Sandgate. Fitton (1836, p. 122) thought that this sand belonged to his second division of the Lower Greensand, i.e. the Sandgate Beds, and he compared the nodules with those found at Shanklin and Parham Park, Sussex; those, however, lie on a lower horizon (*nutfieldensis* Zone). Nodules, with fossils of the *jacobi* Zone, were passed through in the construction of Saltwood railway tunnel and were again referred to the 'second division of the Lower Greensand' by Simms (1843). Topley (1875, p. 128) also attributed them to the Sandgate Beds. Fossils found here by Simms include the type of *Hypacanthoplites simmsi* (Forbes 1845, p. 353).

Where the Folkestone Beds turn inland in a north-easterly direction we find a rapidly diminishing thickness of *regularis–mammillatum* strata. Thin slabs of cherty sandstone with *Leymeriella* from close below the Gault were found during excavations for air-raid shelters in the playing field of Morehall School, Cheriton, and similar slabs lie about the fields around St. Martin's Church, at the top of Horn Street, 2 miles north-west of Mill Point, Folkestone. This is the farthest point west for the *regularis* Subzone in East Kent.

The *mammillatum* Zone could be seen for many years in the railway embankment of the Canterbury branch-line, a quarter of a mile north of St. Martin's Church. The section was mentioned by Topley (1875, p. 147) but has become grassed over since the closing of the line in 1952. As noted by Topley, it showed only *two* nodule-bands instead of the three seen at East Cliff. Topley described the section as follows:

Section of Mammillatum Zone in railway embankment ¼ mile north of St. Martin's Church and ½ mile north-east of Cheriton Church

	ft.	in.
(*a*) Sandy clay with phosphatic nodules	2	0
(*b*) Yellowish-brown sand	2	0
(*c*) Nodules in brown sand		6
(*d*) White and buff sand with stone in places, false-bedded. 6 ft. seen [? *milletioides* Subzone].		

The top nodule-bed yielded species of *Protohoplites*, diagnostic of the *puzosianus* Subzone, and the bottom nodule-bed, though yielding no hoplitids, contained *D. mammillatum* and *B. newtoni* in sufficient numbers to warrant its assignment to the Main *mammillatum* Bed of Copt Point, Folkestone. The *S. kitchini* bed, at the base of the *mammillatum* Zone, is absent. The nodule-beds may be followed up-track on the north embankment of the main Dover–London line for about 150 yards, due south of the Star Inn, Newington. In the most westerly exposure the bottom nodule-bed (bed *c*) is missing and only 6 inches of yellow-brown sand separate the top nodule-bed from the sandstone of bed *d*. West of this point all exposures of the *mammillatum* Zone in East Kent show the *puzosianus* Subzone only.

A disused sandpit just south of the railway bridge at Newington, and about half a mile west of the last locality, shows the junction of the *jacobi* Zone (*anglicus* Subzone) and the *tardefurcata* Zone (*milletioides* Subzone). The *jacobi* Zone consists of about 40 feet of loose current-bedded sand with rare iron concretions, terminating upwards in a line of phosphatic nodules. The nodules may be traced all round the pit-face and a few bespatter the lowest course of stone doggers just above. The nodules are black, oyster- and serpulid-encrusted, and include remanié *Hypacanthoplites* of the *anglicus* group. Shells of brachiopods that used the nodules for anchorage lie broken in the matrix; among them is *Terebrirostra arduennensis* (= *T. incurvirostrum*), known also from the *tardefurcata* Zone (Shenley Limestone) of Leighton Buzzard, Bedfordshire. Above the nodule-bed are 25–30 feet of yellowish greensands with doggers and bands of tough calcareous stone and seams of white spicular sandstone, very like bed 2 of the Mill Point section. The sands are full of *Chondrites*, and fragments of straight-ribbed *Hypacanthoplites* of the *milletioides* group have been found in the sandstones 12 and 20 feet above the nodule-bed. Nodules from the *mammillatum* Zone lie in the subsoil at the top of the pit and it is estimated that only 3 feet of the total thickness of the beds above the *jacobi* Zone are missing in this section.

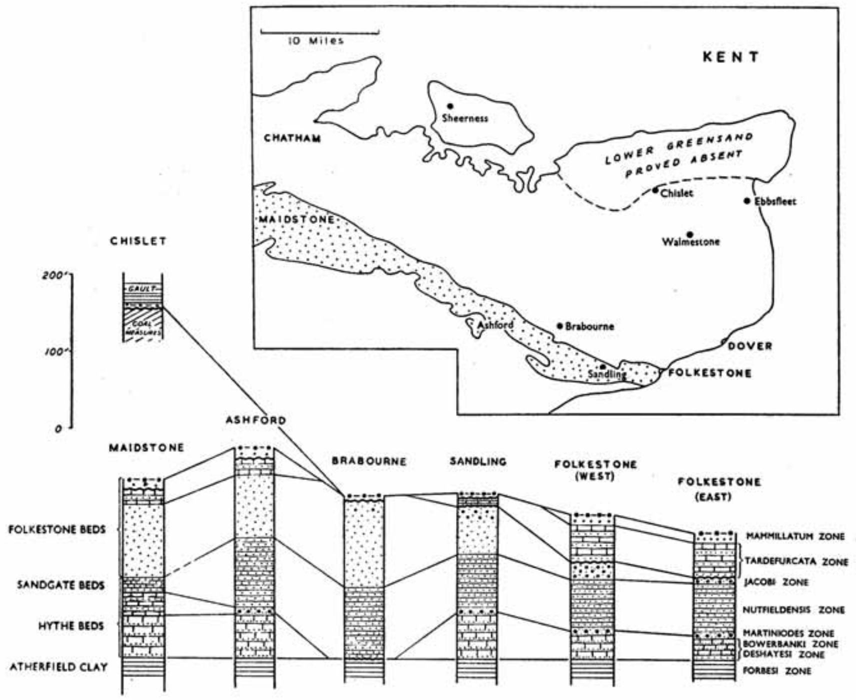
The *anglicus* nodule-bed may be seen in a number of old sandpits between Newington and Saltwood, but no good sections are met with until we reach Sandling Junction. Here, just above the railway station, is a large working in Folkestone Beds, capped by an outlier of Gault. The following section was measured in 1949:

Section of Folkestone Beds exposed in Sandling Junction Sandpit, $1\frac{1}{2}$ miles north-west of St. Leonard's Church, Hythe

	ft.	*in.*
mammillatum Zone		
16. Band of phosphatic nodules in a matrix of green sandy clay, weathering reddish-brown. In places two lines of nodules may be made out; generally they coalesce into a single band. Pebbles of grey-green quartz (up to $\frac{3}{4}$ in.) occur throughout, and flat-sided pieces of claystone (up to 1 in.) in the bottom of the bed	1	0
tardefurcata Zone		
15. Grey-green sandstone with abundant *Oxytoma*. Thin vertical pipings of dark-green clayey sand in upper half	1	1
14. Grey-green sand	3	4
13. Tough grey limestone band, passing laterally into white spicular sandstone with sandy intercalations	1	10
12. Grey-green sand with low-angle current-bedding	1	0
11. Tough grey sandy limestone band	2	2
10. Coarse yellowish greensand, striped by layers rich in glauconite; current-bedded, the bedding contorted at the base	3	0
jacobi Zone		
9. Clusters of small black phosphatic nodules and pebbles disposed in a gently undulating line. Occasional doggers of sandy limestone; matrix coarse yellowish greensand		1–3
8. Sharp yellow sand with lines of iron-staining	3	0
7. Chocolate-reddish-brown sandstone (Red Bed)	1	0
6. Yellowish sand with abundant small pebbles, partially indurated	1	0
5. Very coarse sand with glauconitic and clayey laminae, steeply current-bedded. Phosphatized and semi-phosphatized nodules at the base 18 in. to	2	9
4. Coarse sand with clayey streaks 3 ft. to	3	10
3. Sand as above but steeply current-bedded	12	0
2. Pale sands with wisps and pocks of bluish clay. Rotted ironstone concretions, mainly in top 3 ft.	15	0
1. Sands as above but without concretions (seen in a temporary trench in the pit floor)	10	0
Total about	62	0

The lower part of the succession (beds 1–7) was first referred to the *nolani* Subzone on the strength of ammonite determinations by Spath (Casey 1939, p. 369). Larger collections and more detailed study of the ammonites now show that all the beds up to bed 9 belong to the *anglicus* Subzone of the *jacobi* Zone and are a greatly expanded version of the *anglicus* nodule-band at the base of the Folkestone Beds of East Cliff. The rotted ironstone concretions of bed 2 contain *Hypacanthoplites* cf. *laticostatus* and other forms present in the *anglicus* nodules at Folkestone. They are on the same horizon as the fossiliferous concretions found in the nearby Saltwood Tunnel excavations (Simms 1843).

Concretions in bed 5 (horizon 3 of Casey 1939) are an important source of fossils, containing a varied fauna of mollusca, polyzoa, echinodermata, and brachiopoda. 'They appear to represent aggregations of organic debris that accumulated in hollows on the sea-floor and were cemented by syngenetic formation of calcium-phosphate, the shell substance of mollusca and other carbonate being converted to collophane. Ammonites and gastropods are usually hollow, and the preservation and mode of occurrence of the fossils suggest that the shells were buried rapidly more or less where they died' (Casey 1960*b*, p. 273). Many of the nodules in this bed are cylindrical and are phosphatized only on the outside; others enclose arborescent polyzoa. It can be seen at a glance that these are the same nodules, but in an unrolled and unscoured condition, that occur in the *anglicus* band at East Cliff, Folkestone. *Thetironia minor*, *Pterotrigonia mantelli*, *Modiolus aequalis*, *Chlamys robinaldina*, *Limopsis albensis*, *Glycymeris* (*Glycymerita*) *sublaevis*, *Palaeomoera inaequalis*, and *Tortarctica similis* and other lamellibranchs occur clustered in the nodules, together with *Lamellirhynchia* and broken echinoids. The small trochid gastropod *Margarites* (*Atira*) *mirabilis* is very common here and one remarkable example was found to possess a mould of the intestines (Casey 1960*b*). Another interesting



TEXT-FIG. 5. Comparative vertical sections of the Lower Greensand of East Kent and Maidstone.

feature of this fauna is the apparent symbiotic association of polyzoa and serpulids. Ammonites are rather rare, but *H. anglicus*, *H. simmsi*, and undescribed allies have been found. The 'Red Bed' (bed 7) has contributed the same species of ammonites, and also yields *Neithea quinquecostata*, *Thetironia minor*, *Pterotrigonia mantelli*, '*Rhynchonella*' *deluci*, *Lamellirhynchia caseyi*, and the echinoids *Holaster* (*Labrotaxis*) *cantianus* and *Catopygus* cf. *columbarius* as common fossils.

The black, oyster- and serpulid-encrusted nodules of bed 9 (horizon 5 of Casey 1939) are highly charged with sponge-spicules and minute chips of shell and the enclosed sand-grains are frequently coated with iron; they have yielded *H. anglicus*, *H.* cf. *jacobi*, *H.* aff. *simmsi*, and the lobster *Homarus longimanus*. *Hypacanthoplites* cf. *subelegans* and *H. milletioides* (= *Douvilleiceras?*, Casey 1939), indicative of the *milletioides* Subzone of the *tardefurcata*

Zone, occur rarely in the stone bands (beds 13 and 15) above the *anglicus* Subzone. Bed 13 contains silicified banks of the hexactinellid sponge *Plocoscyphia*, colonies of the polyzoan *Inversaria orbicularis*, and terebelloid worms, and beds 11 and 13 have a fauna of terebratulids and rhynchonellids not yet systematically studied. *Oxytoma pectinatum* occurs throughout and is especially abundant in bed 15.

Resting on the bored top of the *tardefurcata* Zone is the phosphorite band of the *mammillatum* Zone (bed 16), containing at the base angular pieces of claystone and rare fragments of *Hypacanthoplites milletioides* derived from some pre-existing bed in the zone below. Fossils are invariably in a remanié state. The lamellibranchs *Cucullaea glabra*, *Entolium orbiculare*, *Gryphaeostrea canaliculata*, and *Exogyra latissima* are very numerous, the last generally having a rotted shell with a network of infilled *Cliona* borings. The following ammonites have been collected: *Douvilleiceras mammillatum*, *D. monile*, *D. orbignyi*, *D. sp. nov.*, *Beudanticeras newtoni*, *Sonneratia dutempleana*, *Pseudosonneratia sp. nov.*, *Protohoplites* (*P.*) *latisulcatus*, *P.* (*P.*) *michelinianus*, *P.* (*Hemisonneratia*) *puzosianus*, *P.* (*H.*) *gallicus*, *P.* (*H.*) *sp. nov.*, *Otohoplites auritiformis*, *O. spp. nov.*, *Cleoniceras* cf. *quercifolium*, *Protanisoceras raulinianum*, *P. cantianum*. The assemblage is of *puzosianus* age and shows that this *mammillatum*-bed is approximately equivalent to the 'Sulphur Band' of Folkestone.

This important section not only proves the *farnhamensis* non-sequence at the base of the *tardefurcata* Zone, but also demonstrates in a striking manner the disappearance of practically all the Folkestone Beds seen in the cliffs east of Folkestone Harbour. In all, some 60 feet of strata, comprising the *regularis* Subzone, *Sonneratia kitchini* bed, and Main *mammillatum* bed, have been cut out from beneath the *puzosianus* Subzone.

North-west of Sandling Junction the plane of unconformity at the base of the *puzosianus* Subzone is shown very clearly in sandpits south of Brabourne. In File's Pit, at the top of Swan Lane, Sellindge, a quarter of a mile south-east of Horton Priory and 2½ miles north-west of Sandling Junction, the *puzosianus* Subzone, with characteristic ammonites, is split into three lines of phosphatic nodules distributed through 2 feet of glauconitic, pebbly sands and loams. This rests with sharp junction on pale, current-bedded sands with giant foresets; the top 12 to 16 inches of sand is patchily indurated into a yellowish sandrock and is riddled with the same dark-coloured vertical pipings seen below the *mammillatum* Zone at Sandling Junction. Four to ten feet below the top of the sand are sparsely distributed nodules with arborescent polyzoa, exactly like those found in bed 5 of the *jacobi* Zone (*anglicus* Subzone) of Sandling Junction. A similar succession is seen in the Granary Court sandpit, Brabourne Lees, just over a mile and a half north-west of File's Pit and a mile and a half north-east of Smeeth. Here the polyzoan-bearing nodules lie immediately under the *mammillatum* Zone. In the Brabourne area, therefore, the stone bands of the *milletioides* Subzone (already partly eroded at Sandling Junction) and the topmost part of the *anglicus* Subzone have been cut out by the unconformity.

Further evidence of pre-*mammillatum* erosion of the Folkestone Beds was provided by a chance exposure in the underground workings of Chislet Colliery, about 6 miles north-east of Canterbury. Three thousand and twenty yards N. 54½° E. of the North Pit (Downcast) shaft, at a level of −1,016 feet O.D., the Gault was unexpectedly encountered, resting with angular discordance on the Coal Measures. At the base of the Gault, below the *benettianus* and *eodentatus* Subzones, was a conglomerate-bed, 9 inches thick, in which alongside the normal phosphatized fauna of the *mammillatum* Zone were worn slabs (up to a foot in length) of Folkestone Beds sandstone. Some of the slabs were composed of a green siliceous rock not unlike the Ightham Stone (Geological Survey collection).

In Quarrington Wood, about 2 miles north-west of the pit at Brabourne Lees, the *puzosianus* nodule-beds are replaced by an ironstone seam, similar to that found at the junction of the Folkestone Beds and Gault in West Sussex (Worrall 1954).

West Kent

The area of Lower Greensand country considered under this heading extends from Ashford, in the south-east, to the western border of the county at Westerham, 2 miles west of Sevenoaks. From Ashford the outcrop continues its north-easterly trend to Maidstone, where the recession of the Chalk escarpment at the Medway Gap has laid bare a broad triangular expanse of Lower Greensand 6 miles wide. West of Maidstone the strike of the beds changes to WSW.–ENE. and the outcrop steadily diminishes in width, being reduced to a mile and a half at the western end of the region.

There are no fundamental works on the Lower Greensand of West Kent, though there is a voluminous, scattered literature relating to local detail. Easy of access from London, the district is a favourite one for student-parties and the *Proceedings of the Geologists' Association* contain innumerable snippets of information on the Lower Greensand of this region, either in short papers or in excursion reports. The ragstone quarries around Maidstone came under the observation of Fitton (1836; 1845), Bensted (1860; 1862), and Topley (1875), and useful information on the Lower Greensand exposed during the construction of the Sevenoaks railway tunnel was contributed by Evans (1864; 1871). Among the more recent literature mention may be made of papers by E. E. S. Brown (1941), who described the Folkestone Beds and basal Gault in the Wrotham Heath area, by Dighton Thomas (*in* Wright and Thomas 1946), dealing with the Hythe Beds of Dryhill, near Sevenoaks, and by Wells and Gossling (1947), who made a special study of the pebble-beds in the Lower Greensand of East Surrey and West Kent.

Compared with East Kent, the present region shows an increase in thickness of the more arenaceous divisions of the Lower Greensand, the Hythe Beds, and the Folkestone Beds. From the viewpoint of zonal stratigraphy the most important changes are the westwards passage of the Sandgate Beds basal nodule-bed into 60 or 70 feet of rag, hassock, and cherts of Hythe Beds facies and the incoming at the western end of the region of the lower horizons of the Atherfield Clay.

Atherfield Clay. This division crops out in a narrow tract along the foot of the Hythe Beds escarpment, but is seldom exposed and in the field is difficult to distinguish from the Weald Clay below. Over much of the outcrop its precise thickness is unknown. About 30 feet thick at Maidstone, it expands southwards and may double this thickness on the escarpment between Yalding and Linton. It consists mostly of silty clays, grey, blue, yellow, and reddish, with a few calcareous and ferruginous claystone nodules. At the junction with the Hythe Beds it is frequently glauconitic and sandy. Locally it contains seams of fuller's earth.

The junction of the Atherfield Clay and the Hythe Beds may be seen in a pit formerly worked by the Fuller's Earth Union, a quarter of a mile north of Leeds Church, about 4 miles south-west of Maidstone. The following section was measured in 1955 in steeply dipping strata:

Section of Atherfield Clay and Hythe Beds, ¼ mile north of Leeds Church, Kent

		ft.	*in.*
Hythe Beds			
4. Alternation of rag and hassock	estimated	25	0
3. Brown-grey fossiliferous ragstone			6–9
2. Grey-green glauconitic hassock with scattered pale phosphatic nodules; impersistent hard band at base		10	0
Atherfield Clay			
1. Blue, slightly sandy clay, paler at top	about	30	0
	Total about	65	6

The clay has a good fauna of microzoa and from the topmost 10 feet were obtained crushed specimens of the ammonite *Deshayesites forbesi* sp. nov.

The railway cutting at Teston, in the Medway Valley, at one time exposed the junction of the Atherfield Clay and Weald Clay. Simms (1845) noted that 'the beds resting on the Wealden in this locality seem to be identical with the marine clays found at Hythe and at Atherfield in the Isle of Wight. . . . There is also a bed of stone, not a continuous bed, but in concretionary masses, just above the junction, from which I obtained fossils, and which, I consider, represents the Atherfield rocks.' Unfortunately the fossils mentioned by Simms have not been preserved, but the reference to fossiliferous concretionary masses at the base of the clays is strongly suggestive of the Perna Bed. If confirmed, this would be the most easterly known occurrence of the Perna Bed.

The best section of Atherfield Clay in this region was seen by Evans (1864; 1871) about a century ago when the Sevenoaks railway tunnel was cut. His estimate of 50 feet for the thickness of the beds included an upper portion of dark clayey sand containing 'a vast amount of water'—almost certainly the basal sands of the Hythe Beds. From the greyish and blue-coloured sandy clays overlying the Weald Clay he collected many fossils which were later presented to the British Museum (Natural History). Other Atherfield Clay fossils from this locality are in the Meyer Collection in the Sedgwick Museum. Most of Evans's fossils were obtained from cemented masses abounding in *Mulletia* [*Perna*] *mulleti*, and although the zonal ammonite (always rare) was not found, the existence of the Perna Bed is itself proof that the *obsoletus* Subzone of the *fissicostatus* Zone is present. The next higher *forbesi* Zone is denoted by *Ancyloceras mantelli* in the Evans Collection and by *Deshayesites forbesi* in the Meyer Collection, the latter labelled 'Atherfield Clay, top'. The venerids *Resatrix dolabra* and *Pseudaphrodina ricordeana* are well represented in Evans's Collection and the hinge structures of these two species were first illustrated by some of his specimens (Casey 1952*b*, pl. 9, figs. 1, 9). *Deshayesites forbesi* was found in the Atherfield Clay samples from boreholes at Sundridge and at Riverhead, near Sevenoaks, at depths of 198 and 250 feet respectively (Geological Survey Collections). Clearly, at the western end of the region the Atherfield Clay has elements of both *fissicostatus* and *forbesi* Zones and is probably a condensed version of the whole of the Atherfield Clay Series of the Isle of Wight.

Hythe Beds. The Hythe Beds rise from the plain of the Weald Clay as a line of hills and sloping cliffs cut by the valleys of the Medway, Len, Great Stour, Darent, and tributaries. About 45 feet thick in the Ashford district, they expand westwards, reaching a maximum thickness of 150 feet on the escarpment west of Sevenoaks. Over most of the outcrop the beds maintain a 'rag and hassock' facies similar to that of East Kent, but west of Maidstone there is a gradual change to a more sandy type of lithology. One important point of difference compared with the East Kent region is the introduction of chert in the highest beds.

A large quarry at Little Chart, a quarter of a mile south-south-west of the Swan Inn and about 4 miles north-west of Ashford, provided in 1949 a clear section of the greater part of the Hythe Beds, as given on p. 538.

The presence of chert in the residual bed at the top and the absence of a phosphatic nodule-bed at the junction with the Sandgate Beds are typical of the Hythe Beds throughout the whole region. Bed 3 contains *Ch. meyendorffi*, and the association of black nodules and oysters is reminiscent of bed 30 of Otterpool, near the base of the *meyendorffi* Subzone. At Little Chart the nodules are larger and more numerous and it is possible that this bed marks a pause in deposition equivalent to the whole of the *meyendorffi* Subzone of the Hythe district. The same bed, with phosphatic nodules, oysters, and *Ch. meyendorffi*, was found by Mr. Worssam in a small disused quarry on the eastern boundary of Surrenden Dering Park, a quarter of a mile north-east of Rooting and about half a mile south-west of Little Chart. From the ragstone bands below the *meyendorffi* horizon in the Little Chart quarry, mostly picked up loose on the quarry floor, were obtained: *Tropaeum bowerbanki*, *Australiceras gigas*, *Cheloniceras cornuelianum*, *Ch. crassum*, *Dufrenoyia furcata*, and *D. lurensis*, an assemblage indicative of the *transitoria* Subzone of the *bowerbanki* Zone.

Summarized section of Lower Greensand in Little Chart Quarry, 1949

	ft.	in.
Sandgate Beds		
5. Decomposed glauconitic loam	1	0
Hythe Beds		
4. Reddish-brown decalcified hassock with weathered slabs of chert and grey ragstone	4	0
3. Grey ragstone with black phosphatic nodules and abundant *Exogyra latissima*	1	0
2. Grey-green hassock with nodules of ragstone	2	0
1. Alternation of hard grey ragstone and grey-green hassock, estimated	30	0
About	38	0

The next good exposures are in the Maidstone district. From very early times this town has been the centre of a thriving ragstone-quarrying industry and it is surrounded by a number of active and disused workings that give excellent sections of the Hythe Beds. The most famous of all, now defunct, is the *Iguanodon* Quarry, owned by W. H. Bensted, who in the last century made many important finds in this formation. Fitton (1845) noted that the stone in the Maidstone quarries, especially at Boughton, in contrast to that of the other parts of the Kentish Rag tract, assumes the form of continuous and uniform strata and he suggested for this part of the Lower Greensand the term Boughton Group. Many of the courses of ragstone (locally termed lanes) are traceable over a wide area and are given distinctive names by the quarrymen. Thus, a lane just above the middle of the sequence, overlying a bed of hassock full of soft, smutty phosphatic nodules, is called the Coalman, and another, nearer the base, underlying a similar hassock bed, is known as Blackjack. Soft phosphatic nodules are disseminated to a lesser extent through most of the hassock beds and were called 'molluskite' by Bensted (1860). Above the Coalman the beds have lenses and nodules of chert and fossils are sometimes chalcedonized. Some of the ragstones are saccharoidal and many have a high content of microscopic organic debris. Fragments of the calcareous alga *Girvanella intermedia* have been identified by Dr. F. W. Anderson, but none of the ragstones is a true algal limestone.

Ammonites are not common and when found by the quarrymen are often sold as garden ornaments. Of those that have come into my hands, many have been found loose on tip-heaps and others have been purchased from the men; few have been localized precisely in the sections. It is evident, however, that the *deshayesi* and *bowerbanki* Zones of the Lower Aptian and the *martinioides* Zone of the Upper Aptian are all present in the Hythe Beds of the Maidstone district. The Blackjack horizon, which in the easterly part of the district holds an abundance of *Exogyra*, is the boundary of the *deshayesi* and *bowerbanki* Zones, and the Coalman Lane is taken as the base of the *martinioides* Zone. It is impossible at present to fix the boundaries of the different subzones. Since the quarries at Boughton work mainly the last zone, I have elsewhere (Casey 1960*a*, pp. 37–38) proposed to adopt Fitton's term Boughton Group for this upper part of the Hythe Beds of the Maidstone area, which in East Kent is represented by a bed of phosphatic nodules at the base of the Sandgate Beds. The invertebrates of the Lower Aptian portion are essentially the same as described in East Kent.

In the exposure near Leeds Church, mentioned on an earlier page, the beds above the Atherfield Clay have yielded *Deshayesites deshayesi* and *Cheloniceras sp.* (bed 2) and a new species of *Deshayesites* characteristic of the Scaphites Beds of Atherfield (bed 3), thereby proving the *parinodum* and *grandis* Subzones of the *deshayesi* Zone. Another typical *grandis* Subzone ammonite, *Tropaeum hillsi*, was collected by Mr. Worssam from 1 foot 3 inches below an *Exogyra* bed (Blackjack horizon) exposed on the north bank of Mill Pond, 900 yards N. 15° W. of Leeds Church. It was from the Maidstone district that Sowerby obtained some of the specimens used in the original description of this species.

Spot Lane Quarry, Otham, sprawled over a large area of cambered Hythe Beds, has for the past few years shown a good section of the beds in the vicinity of the Coalman Lane. From the hassock just beneath the Coalman, associated with numerous *Exogyra*, *Linotrigonia*, and the belemnite *Neohibolites ewaldi*, I collected *Tropaeum bowerbanki*, *Cheloniceras meyendorffi*, and indeterminate *Dufrenoyia*. At Skinner's Quarry, Brishing Court, near Boughton Mount, south of Maidstone, almost the whole of the Boughton Group is exposed, overlying about 15 feet of *bowerbanki* Zone. Chert and sand, known locally as 'callow', form the top 18 feet, and from between this and the Coalman Lane (called the Newington Lane in this quarry) I have secured a large number of ammonites, mostly with the co-operation of the quarry foreman and the owner, Mr. Skinner. The list is as follows: *Cheloniceras* (*Epicheloniceras*) *martinioides* sp. nov., *Ch.* (*E.*) aff. *debile* sp. nov., *Ch.* (*E.*) *gracile* sp. nov., *Ch.* (*E.*) *spp. nov.*, *Tropaeum benstedi*, *Ammonitoceras sp. nov.* From these fossils it is possible to say that the 20 feet or so of ragstone above the Coalman are the correlatives of Groups VIII, IX, and X of the Isle of Wight, i.e. the 104 feet of strata from the base of the Upper Crioceras Beds to the top of the Upper Gryphaea Beds. It is probable that the unfossiliferous 'callow' is the equivalent of Groups XI and XII of the Isle of Wight, also very poor in fossils, and represents the *buxtorfi* Subzone at the top of the *martinioides* Zone.

The quarries at Tovil, a southern suburb of Maidstone, have fallen into disuse and it is not known which one furnished the type specimen of *Ammonitoceras tovilense*, described by Crick (1916).

Very large workings in Hythe Beds are situated at the Coombe and Postley quarries, about a quarter of a mile north-west of Hayle Place. At Coombe Quarry over 60 feet of Hythe Beds are seen below a thin capping of Sandgate Beds loams. The Boughton Group (*martinioides* Zone) is here about 40 feet thick, this being perhaps little more than a third of the total thickness of Hythe Beds in this neighbourhood. The zone fossil *Cheloniceras* (*E.*) *martinioides* was collected from the Chance Lane, just below a thick development of ragstone and chert (The Flint) and about 8 feet above the Coalman. A specimen of *Cheloniceras* (*E.*) aff. *debile* sp. nov. was also found at the same general level. Twenty feet above the Coalman, in the Thrasher Lane, a thick ragstone band with pockets of rusty-sand ('snuff-boxes'), I collected *Tropaeum* cf. *rossicum*.

The *Iguanodon* Quarry, 75 feet deep, was situated on the west side of Maidstone, south of the main London road. The circumstances surrounding the discovery of the skeleton which is the type of *Iguanodon mantelli*, now in the British Museum (Natural History), have been narrated several times (Mantell 1834; Buckland 1836; Owen 1851; Bensted 1860, 1862; Swinton 1951, &c.). Judging by Bensted's description it was found in the *bowerbanki* Zone, above the 'molluskite hassock' (Blackjack horizon) with frequent '*Nautilus elegans*' (*Cymatoceras pseudoelegans*) and below a thick cherty series (Boughton Group). The limestone was said to abound in ammonites and sharks' teeth (Buckland 1836). The British Museum collections contain dental plates of the chimaeroid fish *Ischyodus thurmanni* and teeth of *Heterodontus sulcatus* and *Hybodus complanatus* labelled '*Iguanodon* Quarry' and in a matrix identical with that of the dinosaur. The types of *Synechodus tenuis*, labelled simply 'Greensand, Maidstone', have the same sort of matrix. Bensted found a tooth of the marine reptile *Polyptychodon continuus* in the 'molluskite hassock', and some 15 feet below the *Iguanodon* level he discovered the carapace of a large turtle, subsequently made the type of a new genus and species, *Protemys serrata* (Owen 1851). The horizon of this last find must fall within the *deshayesi* Zone; Owen remarked on the abundance of sponge-spicules in the matrix of the fossil, which in this and other respects agrees with that of the lectotype of *Tropaeum hillsi*, also from Maidstone.

Not least of Bensted's discoveries in the *Iguanodon* Quarry were beds rich in plant remains in the Boughton Group. Coniferous wood from this quarry is described in Stopes's Catalogue under the names *Pityoxylon benstedi*, *Pinostrobus benstedi*, *P. patens*, *Cedrostrobus mantelli*, *Cedroxylon maidstonense*, *Abietites* cf. *solmi*, and *Cupressinoxylon cryptomeroides*. Unfortunately, the unique type specimens of the angiosperm *Hythia elgari* and the bennettitalian *Bennettites allchini* are not localized closer than 'Maidstone' and it is not known if all were one flora. Bensted's most famous plant discovery, the 'Dragon Tree', excited great interest for many years. Originally thought to be a monocotyledon, it was named *Dracaena benstedii* by König and figured under that name by Mackie (1862). Seward (1896) later transferred it to the cycads, giving it the generic name *Benstedtia*. Finally, Stopes (1911; 1911*a*) showed that it was merely a rotted piece of the woody trunk of one of the higher conifers and commonplace. *Petromonile benstedi*, an organic structure resembling a string of beads, once believed to be a sponge, also occurred in the Boughton Group of this quarry.

A quarry about half a mile south-west of Allington Church, still worked by the Bensted family, has yielded *Cheloniceras* (*E.*) *gracile* sp. nov. in the highest beds exposed, apparently equivalent to the Thrasher Lane of Coombe Quarry. The Blackjack Lane is present at the bottom of the quarry with an overlying hassock crowded with the usual crushed fossils and nodules. *Cymatoceras pseudoelegans* is the dominant cephalopod, both this nautiloid and the belemnite *Neohibolites ewaldi* outnumbering the ammonites, here represented by *Cheloniceras* of the *cornuelianum* type and a doubtful *Australiceras gigas*. This is one of the few horizons in the Mesozoic where nautiloids have an ascendancy over ammonites.

The Town Malling Quarry, East Malling, whence came a specimen of *Ch.* (*E.*) *martinioides* in the British Museum (Natural History), is now overgrown and it has not been possible to trace the provenance of some half dozen specimens of this species in the Maidstone Museum, labelled simply 'Maidstone' or 'Boughton'.

West of the Maidstone area the Hythe Beds increase in thickness and begin to partake of a more sandy character. Large quarries just west of Offham (Brown 1941) show 70–80 feet of glauconitic and sandy ragstone alternating with gritty glauconitic hassock. The greater part of this thickness belongs to the *martinioides* Zone, the only ammonites obtained being *Tropaeum benstedi* and species of *Epicheloniceras* from near the base, both diagnostic of that zone. A conspicuous bed of coarse sandy ragstone, 2 feet thick, with phosphatic nodules at the base (Granny Lane), lies a few feet above the quarry floors and may be the equivalent of the Coalman Lane of the Maidstone area.

A rapid thinning of the *martinioides* Zone takes place west of Offham. In the large rambling quarries at Basted House, between Ightham and Borough Green, about $3\frac{1}{2}$ miles west of the last exposure, the top 70 feet of the Hythe Beds are displayed, of which only 45 feet can belong to the *martinioides* Zone. This zone may in fact be confined to the topmost few feet in which brown and pink chert (Sevenoaks Stone or 'Shatter Rock') is prevalent. Crushed *Tropaeum bowerbanki* and *Cheloniceras* cf. *cornuelianum* occur in the hassock in the bottom 25 feet of the workings. From a hassock bed near the floor of the quarry I collected a piece of a Kimmeridgian *Pavlovia*, in black phosphatic preservation like those from the '*rotunda*-bed' in the Warlingham boring (Allen 1960, p. 161). Weathered surfaces of the ragstone at this locality are good for collecting polyzoa.

A boring sunk to 290 feet, 850 yards S. 9° W. of the George Inn, Trottiscliffe, proved 97 feet of rag and hassock but just failed to bottom the Hythe Beds. The beds were coarse, sandy and fossiliferous; a band between 273 ft. and 276 ft. 3 in. contained crushed *Cymatoceras* and partly phosphatized ammonites (*Cheloniceras* and *Dufrenoyia*) with pebbles and *Exogyra* at the base, probably the Blackjack horizon.

From the large quarry near the Wheatsheaf Inn, West Malling, in the *martinioides* Zone, Brown obtained a petrified stem of the fern *Protopteris fibrosa*, known otherwise only by the type-specimen, from the Turonian of Silesia (Whiteside 1956).

Roadstone quarries at Dryhill, Sundridge, 2 miles west of Sevenoaks, show 60 feet of sharply folded and faulted Hythe Beds, briefly described by Dighton Thomas (*in* Wright and Thomas 1946). In the north face of the present working quarry is a faulted-down block of cherts and coarse limestones of *martinioides* age, with *Epicheloniceras* and *Ammonitoceras sp. nov.* Elsewhere the sandy rag and hassock contains the usual *bowerbanki* fauna of crushed mollusca, with the ammonites *Tropaeum bowerbanki*, *Cheloniceras cornuelianum* and *Dufrenoyia spp.* (= *Deshayesites* of Thomas). Among the nodules scattered through the hassock beds are phosphatized pieces of *Dufrenoyia*, *Cheloniceras*, *Sanmartinoceras* (*Sinzovia*), *Aconeceras nisoides*, and unnamed Aconeceratidae. The strong representation of the last-named family, not otherwise known on this horizon in the Lower Greensand, gives point to my comments on the curious sporadic distribution of this group of ammonites (Casey 1954*c*).

Sandgate Beds. Throughout West Kent the Sandgate Beds present a facies of glauconitic loams and silts generally sterile for the palaeontologist. Though perhaps reaching a thickness of 70 feet in the eastern part of the region, they become exceedingly thin in the Maidstone and Sevenoaks areas, dwindling to as little as 4 feet in places. Records of fossils from the Sandgate Beds at Aylesford (Himus 1939) have not been confirmed and may have been based on discards from a nearby working in Folkestone Beds. At the Basted House quarries, where a few feet of Sandgate Beds are let down into Cenozoic fissures in the Hythe Beds, the quarrymen dug out the silicified trunk of a pine-tree, 12 feet long (Casey 1951*c*), portions of which are now in the Geological Survey Museum.

Folkestone Beds. From about 110 feet at Ashford, the Folkestone Beds thicken westwards to 200 feet or more west of Sevenoaks. They are current-bedded, more or less ferruginous sands, with a few pebbly or silty layers or seams of pipe-clay. Accumulation of the topmost beds in a series of *regularis–mammillatum* troughs has resulted in a more varied lithology. Bands of glauconitic or ferruginous sandstone appear locally close below the Gault; around Oldbury Camp, near Sevenoaks, this part of the formation contains the well-known Ightham and Oldbury Stones, beds of hard green chert and of brown quartzite respectively. Everywhere the junction with the Gault is marked by a few feet of glauconitic sandy clays and clayey sands with phosphorite nodules.

The main mass of the sands is almost completely devoid of fossils, though careful examination frequently reveals the presence of burrows and other structures indicating the work of animals. In places, as at Wrotham, the type of bedding, wind-polished sand-grains and absence of fossils, has raised the question of aeolian formation (Casey 1946). It is now known that such an association does not exclude a marine environment of origin: dune-bedding may be reproduced by the movement of sand-bars under water, and aeolian-type grains may be blown or washed into the sea.

In Eastwell Lane, about a mile north of Ashford, the top of the Folkestone Beds may be seen in sandpits on either side of the road. Just beneath the soil in the eastern pit is the basal nodule-bed of the *mammillatum* Zone with *S. kitchini*, followed downwards by a few feet of yellowish greensand and thin seams of cherty, spicular sandstone as in the *regularis* Subzone at East Cliff. In the 6 miles of country between here and Brabourne Lees we seem to pass over the crest of the *anglicus–puzosianus* unconformity and enter another *regularis–mammillatum* basin. Little more can be learnt about this basin. A ditch 875 yards south-west of the Olive Branch Inn, Westwell Leacon, about 4 miles west of Eastwell Lane, showed a second concentration of nodules below the main bed with the *puzosianus* fauna, and the presence of the *raulinianus* Subzone was confirmed by finding the index ammonite on the nearby ploughed field. Ditches at Harrietsham and an old pit at the top of Weavering Street, Maidstone, showed a *mammillatum*-bed of *puzosianus* age, but neither exposures were good enough for critical study. Diggings made in 1958 for the new Maidstone bypass road entered the *mammillatum* Zone at the southern end of Cottage Wood and just east of Longham Wood, on either side of Chrismill Bridge, west of Hollingbourne, and at the 'clover leaf', north of the Chiltern Hundreds Inn, on the north-east side of Maidstone. Below vivid green sandy clays of the *dentatus* Zone the *puzosianus* nodule band was seen to pass down gradationally to running sands of Folkestone type, but the intervening 4 feet of glauconitic and phosphatic passage-beds failed to yield ammonites diagnostic of a subzone.

Ferruginous nodules picked up from the roadside and allotments at the top of Weavering Street, Maidstone, about 200 yards north of the cross-roads by Birling House, were full of moulds of the gastropod *Anchura (Perissoptera) parkinsoni* and the ammonites *Hypacanthoplites clavatus* and *H. spp.*, indicative of the *anglicus* Subzone of the *jacobi* Zone. I could not find exactly where the nodules came from, though the fine sand clinging to them is like that found here in the middle of the formation.

Folkestone Beds have been extensively dug by the Aylesford Sand Company, north of the village of Aylesford, 2½ miles north-west of Maidstone. The succession seen in 1948 is summarized below.

Summarized section of Folkestone Beds in Aylesford Sandpits

		ft.	*in.*
(Medway Gravels above)			
4. Ochreous sands, pebbly in places, with large lenticles of ferruginous sands full of *Exogyra conica*	about	20	0
3. Yellow sands with wisps of clay and clay balls up to 6 in. diameter	about	15	0
2. Grey silt	about	12	0
1. Silver sands, conspicuously current-bedded in wedged-shaped units resembling those of sand-dunes	about	45	0
	Total about	92	0

The sequence Silver Sands–Silt Band–Coarser Sands is remarkably similar to that described by Gossling (1929) in eastern Surrey, and although we are unable to follow these three divisions through the intervening country, correlation with the Surrey succession may be correct. The probability of the Clay–Silt Band being the Aptian–Albian boundary is discussed in the account of Surrey.

Phosphorite-cemented lumps of grit, either loose or attached to large *Ostrea cunabula*, occur at the base of the Gravels and show that a nodule-bed once existed at the top of the sands. The lenticles in bed 4 suggest the fossilization *in situ* of oyster-banks and yield a disappointing set of long-ranging molluscs. Poorly preserved lamellibranchs in iron concretions are found on the same general horizon at the top of the sandpit by the railway line north of Wrotham and Borough Green Station.

Sandpits in the lower third of the Folkestone Beds at Ivy Hatch, seven-eighths of a mile south-south-west of St. Peter's Church, Ightham, show current-bedded sands with seams of pipe-clay and gravelly layers full of silicified valves of large thick-shelled lamellibranchs, mostly *Epicyprina harrisoni* sp. nov., *Yaadia nodosa*, and *Gervillella sublanceolata*. Most of the shells are broken and the whole deposit suggests a littoral, if not intertidal, environment. *Epicyprina harrisoni*, *Pterotrigonia mantelli*, *Tortarctica similis*, *Panopea gurgitis*, and *Neithea quinquecostata* occur also in the Oldbury Stone. At Styants Bottom, west of Oldbury Hill, loose blocks of stone derived from the Folkestone Beds contain chalcedonized polyzoa and shell debris; and similar derivatives, with silicified sponges (*Plocoscyphia*), have been picked up at various localities between Sevenoaks and Ightham. Silicified wood from the sands at Ightham provided Stopes (1915) with the types of the angiosperms *Cantia arborescens* and the conifer *Pityoxylon sewardi.*

The rest of the exposures dealt with in this region belong to the *mammillatum* Zone and it will be convenient to start with that at Westerham, where the sequence is fully developed, and to follow them eastwards.

Squerrye's main pit, 500 yards east-north-east of Westwood Farm, Westerham, is a vast opening in Folkestone Beds, plainly visible from the heights above Westerham. The junction with the Gault is clearly exposed for about 200 yards along the northern side of the pit, where the following section was demonstrated to the Geologists' Association in July 1953:

Section of Folkestone Beds and basal Gault in Squerrye's main pit, Westerham

	ft.	*in.*
dentatus Zone (*benettianus* and *eodentatus* Subzones)		
16. Grey, glauconitic clay with rusty streaks and iron-stained phosphatic nodules (*Lyelliceras lyelli*, *Prolyelliceras sp.*, *Beudanticeras laevigatum*, *Hoplites benettianus*, &c., in nodules) . . . . . . seen	3	0
15. Grey, glauconitic clay with rafts of green sandy clay and large septarian nodules, flying to bits when tapped; rusty streaks (*Hoplites baylei*, *Lyelliceras*, *Isohoplites*, &c., in nodules)	4	0
14. Blue-green sandy clay with phosphatic nodules scattered throughout and concentrated in a band at the base (*Isohoplites eodentatus*, *D. inaequinodum*)	3	0
mammillatum Zone (*puzosianus* Subzone)		
13. Blue-green sandy clay with scattered putty-coloured phosphatic nodules	1	6
12. Band of putty-coloured nodules in matrix as above (*Otohoplites spp. nov.* in nodules)		6
mammillatum Zone (*raulinianus* Subzone)		
11. As bed 13	1	6
10. As bed 12 (*O. raulinianus*, *D. mammillatum*, *B. newtoni* in nodules, very rare)		4
mammillatum Zone (*floridum* Subzone)		
9. Moss-green sandy clay with a line of putty-coloured nodules at base .	1	10
8. Moss-green sandy clay		10
7. Band crowded with putty-coloured nodules in matrix as above (*D. mammillatum*, *B. newtoni*, *Cleoniceras floridum*, *Protanisoceras acteon*, &c., in nodules)		2–4
6. Blue-grey, dicey clay, slightly sulphurous; incipient development of nodules at top; much glauconite and arenaceous forams. in washed residue . . . . 4 ft. to	5	6
5. Grey, very sandy clay with mauve and green streaks, passing up into bed 6 . . . . 15 in. to	2	6
mammillatum Zone (*kitchini* Subzone)		
4. Yellow-green clayey sands	3	6
3. Band of white phosphatic nodules; densely packed; iron-stained in places; abundant small pebbles (*S. kitchini*, *Cl. morgani*, &c., in nodules, rather rare)		4–9
? *tardefurcata* Zone		
2. Sharp white sand, current-bedded with giant foresets; small pebbles tending to concentrate in lines; a conspicuous 6 in. pebble-bed 20 ft. above base	85	0
1. Silt Band. Buff and grey silt . . . . seen	6	0
Total about	120	0

No dividing line has been drawn between Folkestone Beds and Gault in this section. Above the clean white sands of typical Folkestone facies there is a thick series of clayey sands and sandy clays that grade upwards into Gault. If this section were considered on its own merits, the base of the Gault would best be drawn at the bottom of the *mammillatum* Zone (bed 3). This, however, is the correlative of the *kitchini* bed of East Cliff, Folkestone, unquestionably part of the Folkestone Beds.

This pit is probably the most important in south-east England for studying the succession of ammonite faunas in the *mammillatum* Zone and the lower part of the *dentatus* Zone, for although the abundance of glauconite and contemporary phosphate indicates slow deposition, the sequence is not so condensed and incomplete as it is at Folkestone. At the latter locality, for example, the *floridum* and *raulinianus* faunas lie together in the same remanié bed and the *benettianus* fauna, with *Lyelliceras* and *Prolyelliceras*, is missing (though present in the Chislet and Guilford Collieries). At Westerham the principal source of fossils is bed 7, just above the thick clay bed, which has produced many species of *Cleoniceras* and *Protanisoceras* besides the common forms of *Douvilleiceras* and *Beudanticeras*. Of the minority fauna the forms most commonly met with are *Cleoniceras floridum* sp. nov., *Cl.* (*Neosaynella*) *inornatum*, and *Protanisoceras acteon*. Also present are *Cl. cleon*, *Cl. spp. nov.*, *Cl.* (*N.*) *sp. nov.*, *P. blancheti*, *P. cantianum*, *P. vaucherianum*, *P. sp. nov.*, and very rare *Sonneratia*. Heteromorphs are quite a feature of this locality and horizon. Here also are found frequently the crabs *Notopocorystes stokesi*, *Eucorystes broderipi*, and, rarely, *Homolopsis edwardsi*; lamellibranchs such as *Inoceramus salomoni*, *Leionucula ovata*, *Entolium orbiculare*, *Neithea quinquecostata*, and *Plicatula gurgitis* and the gastropods *Gyrodes genti*, *Anchura* (*Perissoptera*) *parkinsoni*, and *Semisolarium moniliferum* are also typical. Several well-preserved belemnite phragmocones have been obtained from this bed, though guards are unknown; what are generally mistaken for belemnites in this bed are isolated lengths of ammonite siphuncle. The overlying beds of the *mammillatum* Zone are poor in fossils and the presence of the *raulinianus* and *puzosianus* Subzones has been proved only after many years collecting.

Throughout most of its length the pit-face shows a thick band of clay (beds 5–6) resting with sharp junction on the white sands of bed 2, as noted by previous observers (Wells and Gossling 1947, p. 196). In 1954 extension of the pit in a north-easterly direction disclosed a wedge of *kitchini* Subzone between beds 2 and 5, based by a band of white phosphatic nodules with rare ammonites (*Sonneratia kitchini*, *S. sp. nov.*, *Cleoniceras morgani*, *Anadesmoceras baylei*, and *D. mammillatum*). Followed westwards for about 75 yards this nodule-band (bed 3) thinned away and was replaced by an impersistent seam of pebbly ironstone. The overlying sands (bed 4) also thinned away rapidly, so that the ironstone was brought up to form the junction of beds 2 and 5. This pit thus lies on the south-western flank of another *regularis–mammillatum* basin and gives us a chance glimpse of one *mammillatum* Subzone overlapping another.

Important information on the easterly extent of this basin was forthcoming from a Metropolitan Water Board well, one-fifth of a mile south-east of Brasted Railway Station and 2¼ miles north-east of Squerrye's main pit, Westerham. Here, below the stiff grey clays of the Gault, between depths of 59 and 77 feet, the strata set out below were entered.

The bright-green sandy clay (bed 8) is the obvious correlative of the basal *dentatus* Zone and upper *mammillatum* Zone of Squerrye's pit, and beds 6 and 7, containing crushed *D. mammillatum* and *Protanisoceras*, could be recognized as a thinner and sandier version of bed 6 of Squerrye's. But the chief point of interest here is the passage of these clay beds down into greensands and sandstones that have no counterpart at Westerham. This part of the succession is much more like that of the *regularis* and basal *mammillatum* beds of East Cliff, Folkestone, a similarity that would be strengthened if it could be shown that the bottom phosphatic horizon (bed 3) is the *S. kitchini* bed. At all events, it is clear that sedimentation in *regularis* or lower *mammillatum* times was relatively free in this area and that we are near the centre of the basin whose flank is exposed at Westerham.

Strata in Metropolitan Water Board well at Brasted, Kent, between depths of 59 and 77 feet

	ft.	in.
8. Bright green, glauconitic sandy clay with grey-green, black-hearted, phosphatic nodules; pyritic algal threads in top few feet	8	0
7. Pale grey, dicey clay with sandy pockets	1	0
6. Clay as before, but more sandy, passing into	1	0
5. Bright green sandrock	1	0
4. Coarse green sandstone with *Entolium orbiculare*	1	0
3. Yellow-green, somewhat clayey sand with a few phosphatic nodules and phosphatized sponges	2	0
2. Olive-green clayey sand with small pebbles	2	0
1. Yellowish greensand . seen	2	0
Total	18	0

The next good exposures are around Wrotham, about 14 miles east-north-east of Westerham, where the junction of the Folkestone Beds and the Gault may be studied in a number of pits north of Wrotham and Borough Green Railway Station and near Wrotham Heath. Since they all show a similar succession, the one most productive of fossils will be taken as standard. This is a large opening made by the Rugby Cement Company east of Ford Place, on the lane leading to Trottiscliffe, nearly three-quarters of a mile north-east of Wrotham Heath crossroads and adjacent to an older working (Olley's pit) described by E. E. S. Brown (1941, p. 8). Both give the following succession:

Basal Gault and Folkestone Beds exposed in sandpits at Ford Place, Wrotham, Kent

	ft.	in.
Basal dentatus Zone		
9. Very dark, glauconitic, sandy clay with brittle phosphatic nodules (rare *Hoplites* and *B. laevigatum*)	3	0
mammillatum Zone (*puzosianus* Subzone)		
8. Band of dark, gritty phosphatic nodules in a matrix of dark-green, gritty clay		6
7. Dark-green sandy clay with scattered black-hearted, gritty phosphatic nodules	1	0
mammillatum Zone (*raulinianus* Subzone)		
6. Band of white-skinned, dark-centred, gritty phosphatic nodules in a matrix of brown clayey sand		4
5. Brown-weathering, glauconitic loam with scattered white-skinned, gritty phosphatic nodules		10
mammillatum Zone (*floridum* Subzone)		
4. Concretionary band of whitish, friable phosphatic nodules in a matrix of reddish-brown loam		2–6
3. Grey-brown, plastic sandy clay		8
2. Brown clayey sand with wisps of pure clay, scattered small pebbles, and incipient phosphatic nodules. Near the base a few large pebbles (up to 4 in.) of micaceous siltstone	4	0
(Sharp junction)		
? *tardefurcata* Zone		
1. White and buff, coarse to medium grained sands, current-bedded with giant foresets . seen	25	0
Total about	35	6

The current-bedded sands of bed 1 are succeeded abruptly by the *mammillatum*-beds, which form a passage into the blue-grey clays of the Gault. Differential oxidation of the glauconite in these passage beds causes a gradual colour-change upwards from rusty brown to dark green. Both in lithology and fossils the succession is different from that of Westerham and Brasted and these localities may belong to another basin of deposition. The lowest concentration of nodules (bed 4) has yielded ammonites of the *floridum* Subzone, such as *C. floridum* and *C. (N.) inornatum*, though the rarity of heteromorphs and the presence of *Inoceramus coptensis* and species of *Sonneratia* denote a level below the *floridum* nodule-bed of Westerham. Common fossils in this bed at Ford Place are *D. mammillatum*, *B. newtoni*, *Nanonavis carinatus*, *Cucullaea glabra*, *Tortarctica similis*, *Inoceramus salomoni*, *Entolium orbiculare*, and *Semisolarium moniliferum*. A few specimens of the coral *Trochocyathus fittoni* were found in the *raulinianus* Subzone, which is otherwise poor in fossils, but collecting over the years has brought to light an important set of ammonites in the topmost band of nodules (*puzosianus* Subzone) (Casey 1959). Fossil wood, bored by *Terebrimya*, is fairly frequent in bed 8, and here Mr. J. Collins collected several vertebrae and rib-fragments of the dinosaur *Camptosaurus*. Ammonite occurrences are listed below under subzones.

floridum Subzone: *Douvilleiceras mammillatum*, *D. monile*, *Beudanticeras newtoni*, *B. dupinianum*, *Sonneratia spp. nov.*, *Cleoniceras (C.) floridum*, *C. (Neosaynella) inornatum*, *Anadesmoceras?*, *Protanisoceras acteon*, *Hamites* cf. *praegibbosus*. *raulinianus* Subzone: *D. mammillatum*, *D. monile*, *B. newtoni*, *Otohoplites raulinianus*, *Pseudosonneratia sp. nov.* *puzosianus* Subzone: *D. mammillatum*, *D. monile*, *D. orbignyi*, *B. arduennense*, *Otohoplites elegans*, *O. spp. nov.*, *Protohoplites (P.) archiacianus*, *P. (P.) michelinianus*, *Id.* var. *nov.*, *P. (P.) latisulcatus*, *P. (Hemisonneratia) puzosianus*, *P. (H.) gallicus*, *Tetrahoplites* cf. *subquadratus*, *Sonneratia dutempleana*, *S. spp. nov.*, *Pseudosonneratia spp. nov.*, *Cleoniceras sp. indet.*, *Tegoceras gladiator*, *T. mosense*, *Protanisoceras cantianum*.

The supposed differences in the fossils of the various *mammillatum* exposures in this area which puzzled Brown (1941, p. 9) were largely the result of fortuitous and inadequate collecting. Compared with Westerham, however, there is a great increase in the *puzosianus* fauna. Many of the *Protohoplites* and *Otohoplites* are a foot or more in diameter, but the smooth outer whorls are never completely phosphatized and fall to bits on extraction from the matrix.

Cuttings at the cross-roads at Parson's Corner, Snodland, about 4½ miles north-east of Ford Place, show a thin *mammillatum*-bed at the top of a 15-feet section (Bromehead 1924, pp. 8, 9). Its nodules are similar to those in the *puzosianus* Subzone at Ford Place, but larger and thickly studded with pebbles; their fossils include large *Otohoplites* ('undescribed ammonite representing a new genus', Bromehead, ibid.) and numerous *B. newtoni*, suggesting that the bed represents the *raulinianus* and *puzosianus* Subzones combined. Downwards the bed passes into greenish clayey sands with incipient phosphatic nodules at the top and, below, first lenses of light siliceous stone and then doggers of bright-green pebbly sandstone, up to 3 feet thick. The siliceous stone is a felted mass of echinoid radioles, with moulds of rhynchonellids and small *Exogyra*. Valves of the scallop *Entolium orbiculare* occur with shelly debris in the green sandstone, the whole resembling the top of the Folkestone Beds in the Brasted well. Possibly Parson's Corner is near the centre of a *regularis–mammillatum* 'dimple' whose southern rim lies south of Ford Place.

Surrey (*with part of Hampshire*)

From the border of Kent at Westerham the Lower Greensand runs west-south-west through Surrey to Farnham, in the north-west corner of the Weald, and then swings southwards along the fringe of Hampshire to Petersfield, about 40 miles from Westerham as the crow flies. Most of this region is covered by Geological Survey Memoirs (Dines and Edmunds 1929; 1933; Osborne White 1910), and papers by Meyer (1868), Leighton (1895), Gossling (1929), Kirkaldy

(1932; 1933*b*; 1947*a*), Humphries (1956), and Knowles and Middlemiss (1958) deal with the Lower Greensand in various parts. The region has made two important contributions to knowledge of the ammonite succession. Owing to a change of facies in the Sandgate Beds the *nutfieldensis* fauna has been preserved, and in the Folkestone Beds of the Farnham area are ammonites of the basal part of the *tardefurcata* Zone (*farnhamensis* Subzone), known nowhere else in Britain.

Atherfield Clay. In general this consists of 15–60 feet of brown and grey sandy clay and buff loam with concretions of clay-ironstone or calcareous stone at the base (Perna Bed). Underground, north of the outcrop, it may assume a more sandy facies. It is rarely seen. Most of the fossils have been obtained from the Perna Bed (*fissicostatus* Zone), the only sign of the *forbesi* Zone in the eastern part of the region being the presence of *D. forbesi* at Diana's Well, on the north side of Gibb's Brook, Oxted, where the clay is brought up by a fault (Gossling 1936). Good exposures of the junction with the Weald Clay used to be seen in Brown's Brickyard at Woodhatch, north-west of Earlswood Common, Reigate, now overgrown. Butler (1922) and Chatwin (*in* Dines and Edmunds 1933) gave long lists of fossils collected here from the Perna Bed (and now in the Geological Survey Museum). All the common Atherfield forms were found, with hundreds of *Mulletia mulleti* and the ammonites *Prodeshayesites obsoletus*, *P.* aff. *laeviusculus*, and *P. sp. nov.* A similar fauna, but without determinable ammonites, was recorded from Brockham Brickfield (Gossling 1929, p. 218), and a series of lamellibranchs, comprising *Freiastarte subcostata*, *Parmicorbula striatula*, *Pseudolimea parallela*, *Resatrix parva* and *Pseudoptera subdepressa*, was obtained from a road cutting in the clay west of Trashurst, near Dorking (Chatwin, ibid.). Fossiliferous nodules with a Perna Bed fauna were dug up at Binscombe in 1935 and are now in the Godalming Museum.

Rich collections of well-preserved fossils could once be obtained from the base of the clay in the Pease Marsh and East Shalford district, south of Guildford. The best specimens were found in hard grey and brown lumps, pink-shelled and lustrous. Meyer (1868) recorded upwards of 100 species of mollusca, many of which were figured by Gardner (1875; 1876) and Woods (1899–1913) (see also Chatwin, ibid., 1929). *Mulletia mulleti*, *Venilicardia protensa*, *Sphaera corrugata*, *Yaadia nodosa*, and a host of smaller clams (*Anomia laevigata*, *Eonavicula carteroni*, *Aptolinter aptiensis*, *Nuculana scapha*, *Freiastarte subcostata*, *Mediraon sulcatum* sp. nov., *Senis wharburtoni*, *Scittila nasuta*, *Fenestricardita fenestrata*, *Camptonectes cottaldinus*, *Resatrix dolabra*, &c.) and gastropods (*Ovactaeonina forbesiana*, *Ataphrus albensis*, *Tessarolax moreausianum*, *Confusiscala cruciana*, &c.), together with the usual Perna Bed corals, *Holocystis elegans* and *Discocyathus orbingyanus*, a few echinoids (*Toxaster fittoni*, *T. complanatus*) and brachiopods (*Sellithyris sella*, *Sulcirhynchia hythensis*, *Lingula truncata*) make up the bulk of the fauna. The types of *Fossarus munitus* (Forbes 1845), *Dimorphosoma pleurospira* (Gardner 1875), and *Pseudaphrodina elongata* (Casey 1952*b*) came from Pease Marsh and the type of *Scalaria meyeri* (Gardner 1876) from East Shalford. 'The very distinct species from Peasemarsh, resembling *Ammonites leopoldinus* d'Orbigny' (Forbes 1845, p. 355) is *Prodeshayesites obsoletus*.

The whole of the Atherfield Clay, about 60 feet thick, was seen when the railway was cut at Haslemere. Salter (*in* Topley 1875, p. 114; *in* Bristow 1889, p. 48, footnote) noted that here the junction with the Weald Clay lacked the usual concretions but was marked by 'abundant tracks of marine worms, and the *Panopaea* vertical in their old burrows, within an inch or two of the dark marls. A great *Perna*, a coral (*Holocystis elegans*), and numerous other fossils, occur in plenty just above these.' A good set of fossils, including *Prodeshayesites* aff. *obsoletus* and many of the common Perna Bed types, was collected from the old Nutbourne Brickworks, Shottermill, and is now in the Haslemere Educational Museum (Kirkaldy and Wooldridge 1938, pp. 138–9). *Deshayesites fittoni* and the venerids *Resatrix parva* and *R.* (*Vectorbis* *vectensis* denote the presence of the *forbesi* Zone. The arcticid *Proveniella rosacea* sp. nov. gives local character to these clays around Haslemere.

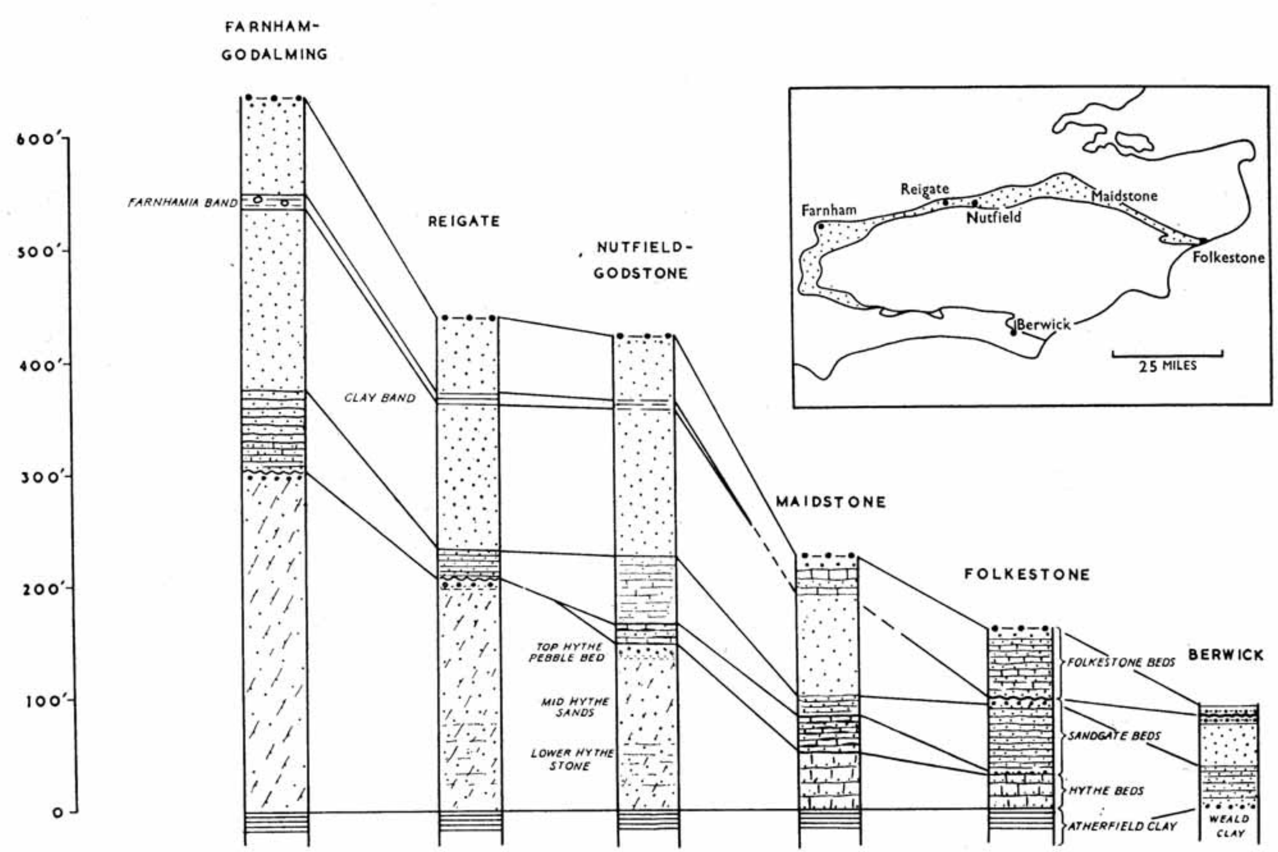
Hythe Beds. In this region the Hythe Beds take on a distinctly arenaceous facies, consisting in general of sand and sandstone with some beds of chert. They thicken westwards from about 160 feet to nearly double that in the Hurt Wood area, south of Shere; but at Guildford they are again only 160 feet thick. Dines and Edmunds (1929, p. 18; fig. 5, p. 24) explained these variations in thickness by supposing that the Hythe Beds were folded and eroded before deposition of the Sandgate Beds. This idea was contested by Kirkaldy (1933*a*) but now receives palaeontological support, as mentioned below. Around Godstone, at the eastern end of the region, Gossling and Bull (1948) and Gossling (*in* Kirkaldy 1947*a*, p. 186) made out the following succession in the Hythe Beds:

Hythe Beds succession in the Godstone area of Surrey

	ft.	*in.*
5. *Top Hythe Chert Bed.* Massive development of chert in the upper, more lenticular development in the lower part	34	0
4. *Upper Hythe Pebble Bed.* Yellow coarse sand with small pebbles	4	6
3. *Mid Hythe Sand.* Fine to medium sands, glauconitic, with much curvilinear ironstone and often current-bedded	72	0
2. *Lower Hythe 'Stone'.* Reddish-brown sand containing layers of soft stone	45	0
1. *Lower Hythe Sand.* Greyish fine sands	10	0
Total	165	6

Gossling (ibid., p. 187) recorded *Tropaeum* cf. *hillsi* from the Lower Hythe 'Stone'; in Outward Lane, leading south from Bletchingley, exposures of this part of the Hythe Beds have yielded *Cheloniceras cornuelianum* and *Ch. parinodum*. This means that both the *parinodum* and *grandis* Subzones of the *deshayesi* Zone are present in the 'Stone'. The presence of the *bowerbanki* Zone in the Mid Hythe Sand is shown by the occurrence of the zone fossil in lane-side exposures in Mid Street, Nutfield (author's collection), and in the pits at Cockshot Hill, and Bell Street, Reigate, and at Taylor's Hill, Godstone. Pits at the last locality, south-east of Godstone Green, present a steep 70-feet face of sand with silicified and iron- and phosphorite-cemented lumps containing fossils. A list of fossils was published by Gossling (1936) and further collections have been made by C. W. Hobley, A. G. Davis, R. V. Melville, C. W. and E. V. Wright, and the author, from which the following are selected—Lamellibranchia: *Barbatia* cf. *baudoniana, Arca sanctae-crucis, Cucullaea cornueliana, Glycymeris marullensis, Modiolus aequalis, Anomia pseudoradiata.* Cephalopoda: *Cymatoceras pseudoelegans, Tropaeum bowerbanki, Australiceras gigas, Dufrenoyia sp., Cheloniceras kiliani*, obese var., *Neohibolites ewaldi.* Echinoidea: *Phyllobrissus fittoni, Holaster benstedi.* Brachiopoda: *Sulcirhynchia hythensis, Cyrtothyris uniplicata, C.* cf. *cantabridgiensis, 'Ornithella' celtica, Oblongarcula oblonga.* Anthozoa: *Oculina hobleyi.* Porifera: *Plocoscyphia sp., Doryderma sp., Geodites* cf. *wrighti.* Reptilia: *Pliosaurus sp.* (tooth). This is the only known source of *Oculina hobleyi*, a surprisingly early occurrence of this genus of corals, which is not otherwise known before the Tertiary (Thomas 1947). Another unique feature of the fauna is the absence of gastropods. Most of the fossiliferous lumps are siftings from the dug sand and are not precisely localized in the section, but the obese variety of *Ch. kiliani*, a *meyendorffi* Subzone type, occurs near the top. Another Lower Aptian *Cheloniceras* was collected by A. G. Davis from the Upper Hythe Pebble Bed at Cockshot Hill, Reigate. At this locality *Quenstedtoceras mariae*, derived from the Oxford Clay and first recorded by Gossling (ibid., p. 183), occurs in the top of the Mid Hythe Sand.

The chert beds are often massive and spiculiferous and it was from such beds at Tilburstow-



TEXT-FIG. 6. Comparative vertical sections of the Lower Greensand of the Weald.

hill and Haslemere that Hinde (1885) obtained specimens to demonstrate the association of sponge spicules with chalcedonic chert. He founded no less than twenty-eight species of *Axinella*, *Dirrhopalum*, *Mastosia*, *Doryderma*, and especially *Geodites*, on isolated spicules, and many of them have since been identified in the cherts of Leith Hill and in washed residues from a clay seam in the Mid Hythe Sand of Bell Street, Reigate (Chatwin, ibid., 1933, pp. 117–18). The last locality and horizon yielded the ostracod *Cytheropteron umbonatum*. The ammonite *Cheloniceras parinodum*, from the lower part of the Hythe Beds, was picked up in the bed of a stream in Vannmoor, about 5 miles east of Hambledon.

The fossils show clearly that the greater part of the Hythe Beds of the Godstone area are of Lower Aptian age and that there is room for the *martinioides* Zone only in the Top Hythe Chert Bed. This agrees with the picture seen in West Kent, where the cherty *martinioides* Zone is thinning west of Offham. The continued westerly dwindling of these top cherty beds is well shown in a series of sections between Godstone and Reigate illustrated by Kirkaldy (1947*a*, pl. 6). At Redhill and Reigate the Upper Hythe Pebble Bed comes to lie close below the Sandgate Beds, with no intervening chert. At Godalming, about 20 miles west-south-west of Reigate, the basal nodule-bed of the Sandgate Beds contains derived Oxfordian ammonites similar to those found in the top of the Mid Hythe Sand at Cockshot Hill and phosphatized ammonites of the *bowerbanki* Zone. The latter include a specimen of *Dufrenoyia furcata* from Holloway Hill, Godalming, in the Meyer Collection in the Sedgwick Museum, and another specimen of the same genus was obtained from an exposure of the nodule-bed in an old quarry 1 mile west of Bramley Church, east of Godalming. No clearer proof could be required for the fact that in this area the Sandgate Beds rest on the eroded top of the Hythe Beds and that the whole of the *martinioides* Zone has disappeared. This bears out the observations of Meyer (1868) and Dines and Edmunds (1929), who believed the Hythe–Sandgate junction to be unconformable in this area. That the line of uplift had an east-to-west trend is suggested by the reappearance of the *martinioides* Zone when the outcrop turns south into the Haslemere district, the presence of this zone being proved by *Cheloniceras* (*E.*) cf. *martinioides* from a well at Blackdown (Haslemere Museum). The recurrence of chert beds at Leith Hill, some 3 miles south of Godalming, may be part of the same pattern of distribution.

Sandgate Beds. In this region the Sandgate Beds have two distinct facies; around Nutfield, near the eastern border of the region, they consist of bands of fuller's earth and cherty and glauconitic sandstones and limestones, with glauconitic loamy sands above (maximum thickness 80 ft.); west of Dorking they can be subdivided into a lower unit characterized by bands and doggers of calcareous stone (Bargate Beds) and an upper unit of ferruginous loams (Puttenham Beds). The western facies has been described in detail by Kirkaldy (1933*b*).

From early times the fuller's earth facies has been exploited in the area between Reigate and Godstone and the pits at Nutfield furnished J. Sowerby (1815) with material for the first description of a Lower Greensand ammonite, *Ammonites nutfieldensis*. The variations in lithology and thickness of the beds are dealt with at length by Gossling (1929) and Dines and Edmunds (1933). Fossils, mostly mollusca, are found chiefly in the calcareous bands within the fuller's earth and include the ammonites *Parahoplites nutfieldensis*, *P. maximus*, *P. sp. nov.*, *Tropaeum subarcticum*, the nautiloid *Anglonautilus undulatus*, the large gastropod *Pleurotomaria anstedi*, and the following lamellibranchs: *Cucullaea cornueliana*, *Freiastarte subcostata*, *Resatrix parva*, *Eriphyla striata*, *Inoceramus neocomiensis*, *Pseudolimea parallela*, *Modiolus aequalis*, *Panopea gurgitis*, *P. mandibula*, *Ensigervilleia forbesiana*, *Linotrigonia* (*Oistotrigonia*) *upwarensis*, *Pterotrigonia mantelli*, and *Entolium orbiculare*. The echinoid *Toxaster fittoni* and the brachiopods *Arenaciarcula fittoni* and *Trifidarcula trifida* also occur. Pieces of coniferous wood are common and the fuller's earth itself yields microzoa (Davies 1916). Bundles of phosphatic tubes 18 inches or more in length traverse the limestone bands;

they belong to an organism of problematical affinities, *Hallimondia fasciculata* gen. et sp. nov. Parahoplitids have been found in the brashy sandstone at the very bottom of the beds at Limpsfield, presumably the source of specimens attributed to the top of the Hythe Beds by Gossling and Hare (*in* Kirkaldy 1939, p. 392). Most other ammonites have been found loose, but *P. nutfieldensis* itself was collected *in situ* in the limestone capping the main seam of fuller's earth in the Priory pit, together with *Tropaeum subarcticum*, and in the limestone underlying the same seam in the Copyhold pit.

The Bargate Beds around Godalming and Guildford have long been of interest, both for their indigenous fossils, which link them with the Lower Greensand of Upware and Faringdon, and for their derivatives, which afford evidence of contemporaneous movement and erosion of Jurassic strata along the edge of the London Platform. Chapman (1894) figured many species of foraminifera and ostracoda and mentioned the occurrence of calcareous algae. Exposures at Guildford provided the types of the corals *Trochosmilia meyeri* and *Isastraea morrisi* (Duncan 1870) and the cirripede *Cretiscalpellum aptiense*, based on a complete capitulum (Withers 1935). But the chief native forms are brachiopods, of which many species have been described and figured by Meyer (1864*b*), Davidson (1874), and Middlemiss (1959), such as: *Rhombothyris extensa*, *Platythyris comptonensis*, *Sellithyris sella* var., *Cyrtothyris cantabridgiensis*, *C. seeleyi*, *Praelongithyris praelongiforma*, *Terebratulina elongata*, *Gemmarcula aurea*, *Trifidarcula trifida*, *Arenaciarcula fittoni*, '*Ornithella*' *juddi*, and '*Rhynchonella*' *antidichotoma*. Lamellibranchs are represented by a few oysters and pectens, gastropods by a solitary *Pleurotomaria*. Cephalopods include the large ammonites *Parahoplites nutfieldensis*, *P. maximus*, and *Tropaeum subarcticum* (Casey 1960*a*, p. 40, text-fig. 12), the nautiloid *Anglonautilus undulatus* and the belemnite *Neohibolites ewaldi*. The echinoid *Cidaris faringdonensis*, columnals of *Isocrinus*, and bones of the dinosaur *Iguanodon mantelli* have also been recorded. The whole fauna was reviewed by Chatwin in 1929 (ibid., pp. 68–71).

Derived fossils found in the pebble-beds at the base of the formation contain a high proportion of fish teeth and ammonites. Arkell (1939) found that 90 per cent. of the ammonites belonged to the *mariae* Zone of the Oxford Clay and from their distribution inferred the existence of an inter-Aptian fault underlying the Hog's Back. This fault is now seen as part of the movements that terminated the Lower Aptian phase of deposition in various parts of Britain and is directly linked with the local disappearance of the *martinioides* Zone.

In general, the only signs of organisms in the Puttenham Beds are *Chondrites*-type borings. Middlemiss, however, found an exposure on the west bank of the River Wey, half a mile west of Headleywood Farm, north of Headley, Hampshire, where the loams contain fossiliferous ironstone lenticles (Knowles and Middlemiss 1958, p. 221). The fossils include echinoids (*Holaster*, *Catopygus*), *Parahoplites cunningtoni* sp. nov., and many other molluscs, the chief being *Limatula tombeckiana* and a gastropod allied to *Margarites* (*Atira*) *mirabilis*. The ammonite shows that the horizon is the same as that of the Iron Sands of Seend, i.e. the *cunningtoni* Subzone of the *nutfieldensis* Zone.

Folkestone Beds. In this region the Folkestone Beds present their typical inland facies of loosely coherent sand with pebbly and clayey seams and veins and doggers of ironstone ('carstone'). False-bedding is prevalent, especially in the upper beds, and the sands have been subjected to varying degrees of iron-staining. As in West Kent, the sands in places have bedding and other characteristics remarkably like sand-dunes (Gossling 1929). Thicknesses vary from about 180 feet in the east to a maximum of 260 feet in the Farnham area. Around Reigate Gossling (1929) made out the following sequence:

4. Upper Pebbly Sands	(50–60 ft.)
3. Clay Band	(10 ft.)
2. Silver Sands	(100–120 ft.)
1. Basal Pebbly Sands	(10–20 ft.)

To these must be added as a fifth and topmost unit the glauconitic loams with phosphatic nodules which form a passage into the Gault. Throughout most of the region fossils are confined to this unit.

The junction with the Gault may be seen in the Coney Hill (Priory) sandpit at Barrow Green, Oxted (Wright and Wright 1948). The succession is similar to that in the western end of Squerrye's main pit, Westerham, little more than a mile to the east, and shows clean, white current-bedded sands followed abruptly by a thick band of clay with the *floridum* nodules above. Exposures around Merstham mentioned by Gossling are now obscured, but that of Colley Lane sandpit, Buckland, west of Reigate (Gossling 1929, p. 249), has improved in recent years. Here the succession is more like that of Ford Place, Wrotham, having the principal concentration of nodules in the *puzosianus* Subzone, but with the *raulinianus* and *floridum* Subzones also present and yielding their characteristic ammonites. Below the basal line of small white nodules (*floridum* Subzone) are 18 inches of brown clayey sands (= bed 2 of Ford Place) which form a sharp line of contact with the underlying current-bedded sands, the contrast between the two sets of beds being heightened when wet. A similar sequence was seen during excavations for the Shere by-pass road.

Lenticles with the oysters *Exogyra conica*, *E. tuberculifera*, and *Lopha diluviana* were found at the base of the Folkestone Beds at Abinger Hammer by Harper and Wilson (1938). No other exposures of palaeontological interest are met with westwards until we reach the Farnham area.

Palaeontological interest in the Folkestone Beds of the Farnham area dates from the discovery by Shepherd in 1934 of ammonites and other fossils in the main mass of the sands, long thought to be barren. Subsequently Wright and Wright (1942*a*) made further discoveries of ammonites, both at Coxbridge, west of Farnham, the site of the original finds, and at High Mill and Runfold, east of Farnham. Originally believed to be Aptian *Parahoplites* of the *nutfieldensis* Zone, and then acanthohoplitids and desmoceratids of the *jacobi* Zone, these ammonites are now known to be of basal Albian age (Casey 1954*a*). The fossils occur in a band, here designated the *farnhamensis* Subzone, that forms the bottom of the *tardefurcata* Zone.

The Coxbridge pit, just off the Alton road, shows about 30 feet of buff, current-bedded sand with irregular masses of carstone. The sands also contain small scattered pebbles, a little glauconite, and an appreciable amount of clayey matter, the last in thin seams or in large buff-grey, slightly phosphatized concretions, which occur in a broad band about 10 feet thick running through the middle of the section. The concretions are found loose in the sand or in the centre of a carstone block and are the main source of fossils.

The standard of preservation is unusually high. Excepting specimens that occur near the outside of a carstone block, shells retain the original test, faintly nacreous when freshly extracted. It is a common occurrence for an ammonite to form the nucleus of a concretion, and when this is split open the chambered whorls of the shell are found to be hollow. Oysters, polyzoa, and other organisms invariably coat the ammonites, both on the outside and on the inner walls of the body-chamber. The latter is also the repository of smaller shells, sponges, pieces of drift-wood, and other sweepings of the sea-floor. The majority of the shells have the appearance of being undamaged at the time of burial. The finds at Coxbridge include—Lamellibranchs: *Arca dupiniana*, *Anomia pseudoradiata*, *Limatula sabulosa* sp. nov., *Acesta longa*, *Oxytoma pectinatum*, *Gryphaeostrea canaliculata* (attached to ammonites), *Glycymeris* (*Glycymerita*) *umbonata*, *Thetironia minor*, *Modiolus aequalis*, *Resatrix* (*Dosiniopsella*) *sp.* Gastropods: *Margarites* (*Atira*) *mirabilis*, *Globularia arduennensis*. Cephalopods: *Farnhamia farnhamensis F. spp. nov.*, *Hypacanthoplites spp. nov.*, *Anadesmoceras sp. nov.*, *Eutrephoceras sp. nov.?* Annelid: *Serpula* cf. *adnata* (attached to ammonites). Echinoid: *Phyllobrisus artesianus*. Polyzoan: *Heteropora michelini*. Porifera: *Plocoscyphia* cf. *labrosa*, *Stelletta* cf. *inclusa*, *Doryderma sp.* Coniferous wood, bored by *Martesia prisca*, is plentiful and in an unusually good state of preservation, microscopic sections showing the cells permeated by fungi. *Farnhamia*, a primitive genus of hoplitids reaching nearly 2 feet in diameter, is the special feature of this district and horizon and has been found nowhere else. The long-ranging genus *Hypacanthoplites* is represented by many new species, some equally large. Another noteworthy feature of this fauna is the presence of recognizable sponges (as opposed to spicules) and the absence of *Exogyra latissima*, *Gervillella sublanceolata*, *Tortarctica similis*, *Cucullaea glabra*, and the other thick-shelled bivalves so common in the coarser, marginal deposits.

Their great thickness and the way they are bedded suggest that in general the Folkestone Beds of this district were laid down rapidly and without any big breaks in the succession. It must be assumed, however, that when the *farnhamensis* fauna existed there were minor pauses in deposition, and that these pauses were long enough for empty shells to lie undisturbed on the sea-bottom and gather an epifauna, though not long enough for complete phosphatization and radioactive enrichment (the usual concomitant of inhibited deposition in the Lower Greensand) to manifest themselves.

At Coxbridge the *Farnhamia* band is about 25 feet below the Gault, the formational boundary being visible in a small opening near the eastern end of the main pit. In the Jolly Farmer and Princess Royal pits at Runfold, about 2½ miles north-east of Coxbridge, the band lies near the bottom of a 50-feet face of sand, 200 yards south of the mapped boundary and at least 80–90 feet below the Gault. About half a mile south-west of Coxbridge, in the Hyde-Crete pit, off the Alton road, it is based by a pebble-bed, 6 inches thick, overlying a vivid green seam and is followed by 40 feet of sand with no sign of the Gault. Exposures at Wrecclesham, six-tenths of a mile south of Coxbridge, show that the varying thicknesses of sand between the *Farnhamia* band and the Gault may be attributed to a period of folding and erosion in mid-*tardefurcata* times.

Pits showing the junction of the Gault and the Folkestone Beds have been worked intermittently at the village of Wrecclesham (formerly Wracklesham) for over a century. They were mentioned by Murchison in 1826 and were fully described by Paine and Wey in 1848. Drew (*in* Topley 1875, p. 142) measured a section near Wrecclesham Church, which was quoted by Jukes-Browne (1900, pp. 96–97) and Dines (*in* Dines and Edmunds 1929, p. 40). The section given on p. 554 was demonstrated to the Geologists' Association in July 1949 (Casey 1951*a*).

Bed 10 contains a condensed *floridum-raulinianus* fauna and besides the usual lamellibranchs yields *D. mammillatum*, *D. monile*, *D. orbignyi*, *Beudanticeras newtoni*, *B. dupinianum*, *Otohoplites raulinianus*, *Cleoniceras floridum*, *C. sp. nov.*, *Sonneratia parenti*, *S.* sp. indet., *Protanisoceras raulinianum*, *P. acteon*, and *Hamites praegibbosus*. From the main nodule-bed of the *regularis* Subzone (bed 5) I have obtained: *Pictetia depressa*, *Leymeriella regularis*, *L. tardefurcata*, *Id.*, var. *intermedia*, *Id.*, var. *densicostata*, *L. pseudoregularis*, *L. rudis*, *L.* cf. *renascens*, *L. consueta*, *Id.*, var. *magna*, *Cleoniceras sp. nov.*, *Anadesmoceras strangulatum*, *A. subbaylei*, *A. spp. nov.* Many of these species also occur in the underlying sand (bed 4). Smooth shards, each supporting a tangled mass of filaments (Pl. 79, fig. 1), are found in bed 5 and are interpreted as phosphorite infillings of *Exogyra* shells that were infested with *Graysonia*. This pit is the best collecting ground for the *regularis* ammonite fauna in England and the main source of *Anadesmoceras*.

In 1955–6 the pit was extended westwards and the beds exposed for nearly 100 yards; the relationship of the *regularis* sediments to the sands below were then seen with unprecedented clarity. The basal bed of the *regularis* Subzone (bed 2) was found to wedge out to the west and to the north and to be replaced by a line of pebbles and phosphatic nodules that passed with angular discordance over the sands of bed 1. Bands of iron-staining, up to one foot thick, mark the topsets of the current-bedded units of these sands and form a parallel series of datum-lines across the pit-face. A particularly conspicuous band lies 8 feet below bed 2 at the entrance to the pit and another 14 feet below that. In the western face, nearly 100 yards distant, the base-line of the *regularis* Subzone oversteps the first band and is brought to within 4 feet of the one next below, the overstep taking effect most rapidly northwards. In the small pit at Coxbridge mentioned above, just over half a mile north of Wrecclesham Church, the *regularis* Subzone is condensed into a single band of pebbles and hard phosphatic nodules with *Anadesmoceras* and a few *Leymeriella*. Two miles north-east of Wrecclesham, in an old pit at the east end of the Farnham by-pass road, opposite High Mill, this band may still be

Gault–Folkestone Beds junction-beds about 50 yards south-west of Wrecclesham Church

		ft.	*in.*
dentatus Zone (pars)			
13. Blue, somewhat sandy clay		3	0
12. Mixture of blue clay and sand with scattered phosphatic nodules (*Hoplites sp.*)		2	6
mammillatum Zone (condensed)			
11. As 12 but sandier and with fewer nodules		1	6
10. Seam of whitish phosphatic nodules			3–6
9. Grey clayey sand with thinly scattered phosphatic nodules			9
8. Buff sand		1	6
7. Grey clayey sand		1	0
6. Coarse buff sand			9
tardefurcata Zone (*regularis* Subzone)			
5. Grey phosphatic nodules in an ill-graded matrix of coarse buff sand and grey clay			2–4
4. Coarse clayey sand with sparse phosphatic nodules		3	6
3. Impersistent seam of soft brick-red sand	6 in. to	1	0
2. Coarse buff sand with occasional friable phosphatic nodules		4	0
tardefurcata Zone (? *milletioides* Subzone)			
1. Coarse buff sand, streaky iron-staining, small-scale current-bedding, some carstone near base		40	0
	Total about	60	0

traced, though the pebble-studded nodules are more thinly scattered. Nodules with *Anadesmoceras*, *Leymeriella*, and *Inoceramus coptensis* may be picked out from under the gravel in another old pit by the roadside at Wiley Mill, three-quarters of a mile west of Wrecclesham. Evidently a *regularis–mammillatum* basin was centred just east of Wrecclesham and these exposures show the first stages of wedging out of the *regularis* sediments towards the margins of the basin.

The section set out on p. 555 was measured in 1947 in the old pit on the Farnham by-pass just mentioned.

The various *mammillatum* beds are better separated than at Wrecclesham, though still condensed. Bed 4 seems to be layers of sand and clay reworked; the clay is often in small strips as though parts of a sheet broken up. The white nodules are like those in bed 10 at Wrecclesham; the black-centred ones in the same bed were apparently derived from a clay seam now sorted in with the sand.

South of the Farnham area the nodule-beds below the Gault have yielded only fossils of the *mammillatum* Zone, as in the roadside pit at the cross-roads three-quarters of a mile south-west of Kingsley Church and in the old disused sandpit 160 yards south-west of the cross-roads at Blackmoor. A feature of these exposures is the increased pebbly content of the beds. A mile and a half farther south a sandpit 200 yards west of Aldersnap Farm, Petersfield, described by White (1910, p. 15), and Kirkaldy (1935, p. 531) shows the junction of the Folkestone Beds and Gault as a thin seam of glauconitic grit with pebbles and phosphatic nodules.

White (1910, p. 19) recorded a section, no longer visible, near Stroud Farm, a mile and a quarter west of Petersfield, in which the junction-bed contained pebbles but no phosphatic nodules. Between Farnham and Petersfield the main mass of the sands, frequently striped with clay at the top, have yielded only driftwood and obscure traces of shells.

Attempts to trace the band with *Farnhamia farnhamensis* beyond the Farnham area have been unsuccessful. I am of the opinion, however, that this band, with its argillaceous content

Gault–Folkestone Beds junction-beds, east end of Farnham by-pass

	ft.	*in.*
dentatus Zone (? *bennetianus* and *dentatus-spathi* Subzones)		
7. Inky-blue clay with phosphatic nodules, passing up into grey clay with *Hoplites* . . . . seen	4	0
dentatus Zone (*eodentatus* Subzone)		
6. Ill-graded sand and clay with many blue-black-hearted phosphatic nodules. *Isohoplites, Douvilleiceras*	3	6
mammillatum Zone (*puzosianus* Subzone)		
5. Yellow-grey sand with scattered small pebbles and black-hearted, slightly pyritic, phosphatic nodules, getting clayey upwards. *P.* (*H.*) *puzosianus* .	3	0
mammillatum Zone (? *raulinianus* Subzone)		
4. Ill-graded coarse sand and clay (weathering brown) with white- and black-hearted phosphatic nodules. *D. mammillatum, B. newtoni* (abundant)	1	0
mammillatum Zone (?*floridum* Subzone)		
3. Buff coarse sand, clayey towards top, with scattered small pebbles; phosphatic nodules dotted throughout and in a line at top. *D. mammillatum, B. newtoni*	5	0
tardefurcata Zone (*regularis* Subzone)		
2. Band of small pebbles and pebble-studded hard phosphatic nodules. *Leymeriella* . . . . 6 in. to		9
tardefurcata Zone (? *milletioides* Subzone)		
1. Buff coarse sand . . . . seen	10	0
Total	27	3

and evidence of restricted deposition, has its sedimentary expression in the Clay Band of the Reigate area. Heavily charged with glauconite and silt, this Clay Band marks an episode of slow, tranquil deposition, in contrast to the periods of rapid accumulation of sandy detritus indicated by the Silver Sands below and the Upper Pebbly Sands above. Its position in the sequence, about two-thirds of the way up, supports this correlation. East of Reigate the Clay Band is replaced by a slightly coarser facies, the Silt Band, which may be followed into the Westerham district, on the county boundary. The reappearance of a conspicuous silt band at the same general stratigraphical level at Aylesford, north of Maidstone, has been commented on in the section on West Kent. Since this Clay–Silt Band runs parallel with the edge of the London Platform, i.e. the old shore-line, it is unlikely to be diachronous. As a stratigraphical aid to division of the Folkestone Beds the Clay–Silt Band has proved invaluable in the country between Reigate and Westerham (Kirkaldy 1947*a*). If I am correct in correlating this Band with the *farnhamensis* Subzone of Farnham, it now acquires an added significance, for its lower limit is the dividing-line between the Aptian and the Albian.

In the marginal areas of the basin, at Folkestone and Eastbourne, there was a definite break in sedimentation at the beginning of the Albian during which deposits of *jacobi* age were reduced to a remanié.

Sussex

The Lower Greensand outcrop swings sharply round Petersfield and continues through Sussex in an east-south-easterly direction towards Eastbourne. At the western end of the region, around Midhurst, the formation is about 580 feet thick and has the same broad lithological divisions as in Kent and Surrey. At Washington, about 17 miles south-east of Midhurst, it is reduced to 350 feet; followed thence to the coast it becomes progressively thinner and the lower divisions, the Atherfield Clay and the Hythe Beds, eventually lose their identity. Finally, under cover of the alluvium around Eastbourne, the whole series passes into glauconitic loams with phosphatic nodules at the base of the Gault. Much of the region is covered by three Geological Survey Memoirs (Reid 1903; White 1924, 1926) and other contributions have been made by Kirkaldy (1933*b*; 1935; 1937), Kirkaldy and Wooldridge (1938), Casey (1950), and Humphries (1956). Less is known about the palaeontology of the Lower Greensand of Sussex than of any other part of the Weald.

Atherfield Clay. Chocolate-brown, blue, and grey silty clays, perhaps reaching a thickness of 60 feet, have been described from the western part of the region. No doubt they have a similar fauna to that found at Shottermill, just over the county boundary. Unfortunately, the exposures at Harwoods Green, about a mile and a half north-west of Pulborough, seen by Fitton (1836, p. 156) and from which Martin (1828) obtained a large fauna, including ammonites, no longer exist. In the extreme east of Sussex, in the Cuckmere Brick Company's pit by Berwick Railway Station, a thin seam of small grey nodules and rolled fossils at the base of the Lower Greensand has yielded *Prodeshayesites sp.* and *Deshayesites forbesi* (? = *D. deshayesi*, Kirkaldy 1937, p. 119), suggesting that it is a highly condensed remanié of the whole Atherfield Clay Series.

Hythe Beds. About 220 feet of sandstone with chert beds at the top are present in the Petworth area (Kirkaldy 1939, p. 393), the chert beds, with seams of spicular stone, descending to lower and lower horizons eastwards. East of the Arun there is a change to a calcareous facies. At Thakeham, 10 miles south-east of Petworth, the Hythe Beds are represented by a greatly diminished thickness of rag and hassock, not easily separable from the Bargate Beds. Attenuation of the beds, accompanied by progressive loss of ragstone, is evident as the formation is followed still farther eastwards and east of Streat they appear to be overstepped by the Sandgate Beds (Kirkaldy 1937, p. 107).

Hinde (1885) thought that the beds of spicular stone and chert were derived from great banks of siliceous sponges whose skeletons were broken up by currents before burial, and Kirkaldy and Wooldridge (1938) explained the distribution of these beds around Midhurst and Haslemere by picturing the sponge-banks spreading northwards during the deposition of the Hythe Beds. Humphries (1956) believed that the chert was of primary origin and not linked with occurrences of sponges. No ammonites have been found in the Hythe Beds of this region, but from their conformable relations and lithological continuity with the Sandgate (Bargate) Beds it may be inferred that the *martinioides* Zone is present in the topmost beds in the western part of the region.

Sandgate Beds. Between Midhurst and Pulborough the Sandgate Beds are about 150 feet thick and have a lower unit of calcareous stone (Bargate Beds) similar to that of west Surrey. Above are ferruginous loams with sporadic fossiliferous concretions, followed by pale micaceous sandstone (Pulborough Sand Rock) and dark silty clay (Marehill Clay). Eastwards the whole series passes into glauconitic loams of rapidly diminishing thickness.

Easebourne Quarry, north-east of Midhurst, shows the lower parts of the Bargate Beds and has yielded a small fauna comprising the annelid *Rotularia concava*, the echinoid *Toxaster fittoni*, brachiopods ('*Ornithella*' *juddi*, *Trifidarcula trifida*), lamellibranchs (*Panopea mandibula*, *Entolium orbiculare*, *Venilicardia sowerbyi*), a gastropod (*Pleurotomaria anstedi*), and the following cephalopods: *Anglonautilus undulatus*, *Parahoplites nutfieldensis*, *P. maximus*, *P. sp. nov.*, and *Tropaeum subarcticum* (Kirkaldy and Wooldridge 1938, p. 142; and A. H.

Gunner Coll.). The Brydone Collection in the Sedgwick Museum contains *P.* cf. *maximus* and *P. sp. nov.* from Upperton, near Petworth, and other parahoplitids from the Bargate Beds of Pulborough are in the London museums. The latter include a distorted nucleus found by Fitton (1836, p. 157) in 'the lowest members of the sands' near Pulborough and described by Spath (1930*a*, p. 441) as a new species, *P. sussexensis* (GSM 46131).

Ironstone concretions in the overlying loams have long been known to yield fossils from occurrences first described at Parham Park (Mantell 1822, p. 72; Martin 1828, p. 31). Other localities are Park Lane, Pulborough, a lane 300 yards west of Muttons Farm, near Ashington, June Lane, Midhurst, and the river cliff east of Habin Bridge, near Rogate (reached only by wading or by boat). The fossils, which occur as clustered moulds, were listed by Kirkaldy (1937, p. 118) and are revised herein. Characteristic species are—Lamellibranchia: *Nuculana scapha, Cucullaea cornueliana, Pterotrigonia mantelli, Cuneolus lanceolatus, Senis wharburtoni, Chlamys robinaldina, Entolium orbiculare, Neithea syriaca, Gervillella sublanceolata, Ensigervilleia forbesiana, Oxytoma pectinatum, Resatrix parva, Thetironia minor, Nemocardium (Pratulum) ibbetsoni, Venilicardia sowerbyi, Lucina cornueliana, Parmicorbula striatula, Panopea gurgitis.* Gastropoda: *Ringinella albensis, Dimorphosoma vectianum, Anchura (Perissoptera) robinaldina, Tessarolax moreausiana, Eulima melanoides, Atresius fittoni, Mesalia (Bathraspira) neocomiensis, Gyrodes genti, Acmaea sp.* Brachiopoda: *Lamellirhynchia* cf. *caseyi*, '*Rhynchonella*' *parvirostris*. Echinoidea: *Toxaster fittoni*. The rudist *Toucasia lonsdalii*, the cucullaeid *Cryptochasma ovale* gen. et sp. nov., and the gastropods *Nerinea sp. nov.* and *Nerita sp. nov.*, also occur, linking the deposit with the Iron Sands of Seend. Cephalopoda are unknown in these loams, though their stratigraphical position and similarity to the beds with ironstone concretions in Group XIV at Shanklin leaves little room for doubt that they belong to the *cunningtoni* Subzone. Fresh samples from depth frequently show the loams themselves to contain fossils, as at Ashington (Kirkaldy 1937, p. 116) and in the Hopton Wood borings, described below. The succeeding Pulborough Sand Rock and Marehill Clay have yielded only plant remains, including fronds of *Weichselia reticulata*. In the eastern half of the region the Sandgate Beds are apparently devoid of organic content.

Folkestone Beds. Over most of the region the Folkestone Beds consist of white, yellow, or reddish sands, strongly current-bedded, and with seams of pebbles and clay. They are involved in the general easterly dwindling of the Lower Greensand of this region. Over 200 feet thick at Petersfield, they are reduced to half that thickness at Washington, some 25 miles farther east. Beyond Washington they are apt to change to an argillaceous and glauconitic facies and near Eastbourne the whole division is assimilated into the basement-beds of the Gault. Change of facies may take place with surprising rapidity, as in the Small Dole area, where the upper part of the division passes into an argillaceous unit, here termed the Hopton Wood Clay. Fossils have been found only in the glauconitic and clayey developments.

The southwards transition of the *mammillatum* Zone from its normal facies of glauconitic loams with phosphatic nodules to a thin band of pebbles may be seen in the Petersfield area, as mentioned above. Now cemented into an iron-grit, this band of pebbles may be followed for nearly 20 miles through Sussex, forming a knife-sharp junction with the Gault. Such continuity is remarkable when it is considered how variable are these beds elsewhere. It would seem that this part of the outcrop coincides with the rim of a *regularis–mammillatum* trough and that the strike of the beds, ESE.–WNW., is the axis of a mid-*tardefurcata* fold. Immediately the outcrop is deflected south of this axis the *regularis–mammillatum* sediments reappear. The incoming of the normal *mammillatum* facies may be seen in two old sandpits on either side of the Horsham road by West Winds Poultry Farm, a mile north of Steyning (Kirkaldy 1935, pp. 526–7), which show wisps of dark glauconitic sandy clay and phosphatic nodules with *D. mammillatum* and *B. newtoni.*

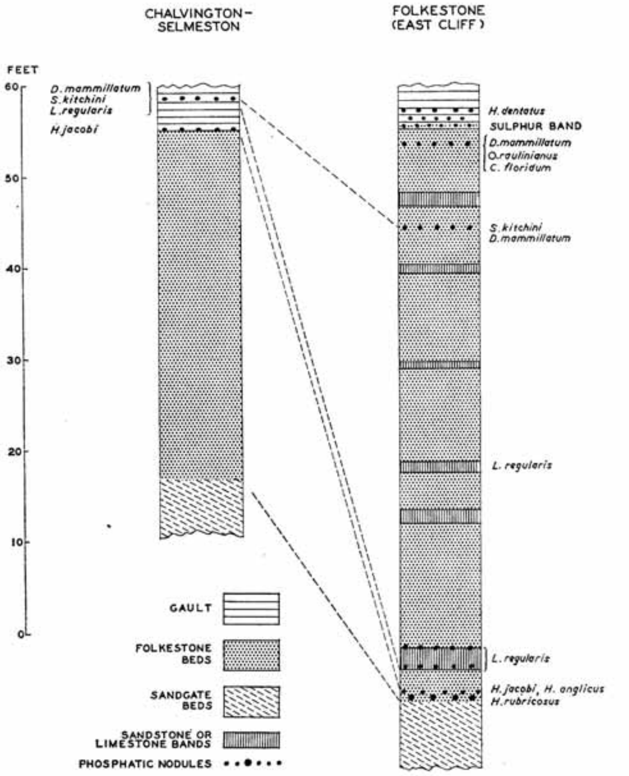
A big step forwards in the study of the Folkestone Beds of this region was made in 1956 when the British Portland Cement Manufacturers put down a series of exploratory borings in the fields east of Hopton Wood, Small Dole, a mile and a half north-east of Upper Beeding. Thanks to the good offices of Mr. Clements of the British Portland Cement Manufacturers I was able to keep drilling operations under close observation and to examine the samples fresh from the core-barrel. Since all the borings showed a similar succession, it will suffice to give details of one, boring number 9a, situated on the eastern edge of Hopton Wood.

British Portland Cement Manufacturers' No. 9a boring, Hopton Wood, Small Dole

	Depth in feet
Gault	
dentatus Zone (*dentatus–spathi* Subzone)	
Brown-weathered clay with rotten fossils	0–10
Dark grey, slightly brown-tinged, micaceous clay (*H. dentatus*)	10–25
dentatus Zone (*benettianus* Subzone)	
Dark grey, slightly silty and micaceous clay with algal filaments, becoming more silty and glauconitic downwards and passing into bed below (*Hoplites*, *Lyelliceras*, *Eubrancoceras*, *Beudanticeras*, and numerous *Protanisoceras moreanum*, all with iridescent test)	25–40
Hard grey-green glauconitic sandy clay with pockets and channels of sand; algal filaments and a few dark phosphatic nodules	40–48
dentatus Zone (*eodentatus* Subzone)	
Hard dark-green glauconitic loam with rafts of clay and pockets and channels of coarse sand; sandy phosphatic nodules and small pebbles; pyritic nodules at top; hard pebbly band at 54 ft.–54 ft. 6 in. (*Hoplites* or *Isohoplites* at 53 ft.)	48–56½
Folkestone Beds	
? *mammillatum* Zone	
Band of dark, gritty phosphatic nodules and small pebbles in glauconitic loam	56½–57
tardefurcata Zone (*regularis* Subzone)	
HOPTON WOOD CLAY. Dark-grey, non-calcareous clay with hard, flat, whitish nodules, especially at top, a few pyritic nodules and numerous algal filaments; some threads of glauconitic sand; washed residue full of glauconite and mica, a few forams. *Aconeceras* and *Leymeriella* with iridescent test; crustacean limbs fairly common	57–69
? *tardefurcata* Zone (*milletioides* Subzone)	
Bright-green glauconitic sandy clay with phosphatic nodules, some gritty, some not	69–72
? *jacobi* Zone	
Grey silt with threads of white sand, becoming clayey downwards and passing into	72–84
Bright-green glauconitic sandy clay with pink powdery traces of fossils, passing into	84–85
Clayey glauconitic sand, weathering white	85–92½
Dark-green glauconitic loam with sandy pockets; line of small pebbles and crushed fossils at base	92½–95½
Sandgate Beds	
Grey-green sandy clay	95½–106
Bright-green glauconitic loam with rotted fossils, mostly *Exogyra*	106–115
Grey-green clayey sand and sandy clay, passing into	115–136
Bright-green glauconitic loam with traces of fossils	136–137

A clay bed, 10 to 13 feet thick, was proved in all the borings below the presumed *mammil-*

latum nodule-bed; its existence was unexpected, there being no sign of it at the outcrop, barely a quarter of a mile to the north. Dark grey in colour and with iridescent fossils, it seemed indistinguishable from the Gault save in its non-calcareous property. Its most surprising feature, however, is its fauna, the dominant fossil being *Aconeceras* sp. nov., with other ammonites, *Leymeriella* cf. *regularis* and *Anadesmoceras*. Apart from two tiny scraps recovered



TEXT-FIG. 7. Comparative vertical sections of the basal Gault and the Folkestone Beds of the Chalvington–Selmeston area of Sussex and of Folkestone, Kent (modified from Casey 1950).

from the nodule-beds at Leighton Buzzard and another from the Shenley Limestone of the same locality, no aconeceratids have been seen before on this horizon. Moreover, the nearest place where the *regularis* Subzone is known in a clay facies is Hanover, north Germany. The geographical extent of this remarkable bed, here designated the Hopton Wood Clay, is unknown. Hudson's Red Sand Pit, Hassocks, 5½ miles north-east of Small Dole, shows a return to the iron-grit facies at the junction with the Gault. The presence of the Hopton Wood Clay farther south is strongly suggested by a record of 'brown clay, not effervescing with acid as the rest of the Gault does, with hard white nodules (? phosphatic)'. This was found between seams of greensand at the base of the Gault at a depth of 1,275 feet in a well at Warren Farm

Industrial School, 2½ miles north-north-east of Rottingdean (Edmunds 1928, p. 194). It may be identified more positively at the surface near Willingdon, as mentioned below.

The whole of the Folkestone Beds in these borings at Small Dole had an unusually high clay content and the boundary with the Sandgate Beds was not easy to fix. Vast quantities of clayey sediment poured into the area during the deposition of the Gault; the borings proved no less than 165 feet of *dentatus* Zone, with an unusually thick and fossiliferous *benettianus* Subzone, not previously recorded in Sussex, though obvious enough in Hudson's Red Sand Pit, Hassocks, where white phosphatic *Lyelliceras* and *Beudanticeras laevigatum* occur about 7 feet above the iron-grit.

The next fossiliferous exposures of the Folkestone Beds are east of Lewes. A large sandpit at Manor Farm, 300 yards north-west of Chalvington Church, formerly exposed the junction with the Gault for a distance of nearly 200 yards and was described by Kirkaldy (1935, p. 520) as follows:

Section formerly seen in sandpit at Manor Farm, Chalvington

		ft.	*in.*
'Gault'			
8. Green glauconitic sandy clay with lenticles of reddish-brown clay	1 ft. to	1	6
7. Discontinuous layer of white phosphatic nodules and pieces of bored wood			0–3
6. Green glauconitic sandy clay	1 ft. 6 in. to	3	0
5. Continuous layer of nodules and wood			3–6
Folkestone Beds			
4. White medium sands faintly speckled with grains of glauconite	1 ft. 6 in. to	3	0
3. Brown sand with scattered quartz pebbles up to a quarter of an inch in diameter		2	0
2. White sand as in bed 4		6	0
1. Greyish, slightly clayey sand with a few soft nodules of ironstone	seen	2	0
	Total	18	0

A small section was still visible in 1950 and furnished me with diagnostic fossils (Casey 1950). Those from bed 5 included the brachiopod *Lamellirhynchia caseyi* and several species of *Hypacanthoplites*, including *H. jacobi*, *H. clavatus*, and *H. elegans*, showing that the bottom of the 'Gault' here lies in the *anglicus* Subzone of the *jacobi* Zone and is on the same horizon as the base of the Folkestone Beds at East Cliff, Folkestone. The upper bed of nodules (bed 7) yielded an entirely different set of ammonites—*Leymeriella tardefurcata*, *L. regularis*, *Sonneratia* aff. *parenti*, *S.* cf. *sarasini*, *Anadesmoceras* aff. *baylei*, *D.* aff. *mammillatum*, *B. newtoni*—indicating a remanié of the *regularis* and *kitchini* Subzones comparable with that of Band II of Leighton Buzzard. Since there must have been a long period of time during which the *anglicus* nodules were scoured out and rolled on the sea-bed, we may infer a missing interval at the base of the *tardefurcata* Zone. This means that the glauconitic bed 6 is probably of *milletioides* age and equivalent to the greensand bed (bed 2) overlying the *anglicus* nodules at Folkestone. The two ammonite horizons were traced in a number of old diggings around Chalvington, Selmeston, and Berwick (Casey 1950), but a different succession was seen in the roadside banks opposite Willingdon Mill, half a mile south of Polegate Railway Station. Excavations on this site revealed the basal nodule-bed with *Hypacanthoplites*, followed upwards by olive-green glauconitic sandy clay and then a thin sandy development of the Hopton Wood Clay, with phosphatic *Leymeriella*. Indications of the *mammillatum* Zone were found still higher, not mixed with the *tardefurcata* fossils (Casey 1950, p. 280). The *anglicus* nodule-bed abounds in fossil wood, as noted by Mantell (1822), p. 76) and this is almost certainly the horizon of the pine cone *Pinistrobus* [*Zamia*] *sussexiensis*, obtained by Mantell (1843, p. 34) from Selmeston, and of the coniferous wood *Protopiceoxylon edwardsi*, which Stopes (1915, p. 81) described from Berwick Green. The Luccomb Chine plant-bed, in the Isle of Wight, is only slightly earlier (*rubricosus* Subzone).

It is doubtful if the underlying sands of the Folkestone Beds persist south-eastwards much beyond Willingdon. They had disappeared already at Willingdon Laundry, 150 yards north of Hampden Park Station, where a well proved only loams of Sandgate Beds type between the Gault and the Weald Clay (Kirkaldy 1937, p. 107). Eight feet of yellow sand, presumably representing the Folkestone Beds, are reported at Hydneye, 650 yards north-north-east of the last locality, but the deep wells at Eastbourne have furnished no evidence of this division of the Lower Greensand. Here it may be assumed that the process of assimilation of the Folkestone Beds by the Gault is complete (Casey 1950, p. 286).

The Western Outliers

For 50 or 60 miles west of the Weald proper the Lower Greensand is hidden beneath a cover of younger strata and when it emerges again it is found only in patches, widely separated, extending from near Aylesbury and Oxford, through Berkshire and Wiltshire, to the neighbourhood of Shaftesbury. This marginal area of Lower Greensand is essentially the record of two overspills from the Wealden Basin that carried the sea westwards over the folded and faulted Jurassics. These two transgressions occurred in *nutfieldensis* and *mammillatum* Zone times and it will be convenient to describe the beds under those headings.

Nutfieldensis Zone. Deposits of *nutfieldensis* age which are strewn along the forward edge of the Gault in Berkshire and Wiltshire probably represent a number of separate marine embayments that existed there during the Lower Greensand period and their present distribution is not necessarily the result of subsequent denudation. Each of these groups of outliers has a lithological and faunal character of its own and the manner in which they are entrenched into the Jurassic and the nature of the faunas suggests that the shore-line did not lie far west of the present outcrop.

The best known of these outliers is at Faringdon, Berkshire, described by Mantell (1839; 1844), Austen (1850), Sharpe (1854), Meyer (1864*a*), and Davey (1874). An excellent up-to-date account of them is given by Arkell (1947*a*), who used the following stratigraphical divisions:

4. Sands with chert and ironstone
3. Sandy clays
2. Red gravel
   [pebble-bed at junction] } The Sponge Gravels
1. Yellow gravel

The sponge gravel, where present, generally rests on Kimmeridge Clay, though in places it overlaps on to Coral Rag. Pieces of Coral Rag occur in the gravel, together with many derived Kimmeridge Clay fossils. The maximum thickness of the beds is between 160 and 190 feet.

The Sponge Gravels are current-bedded sand-and-gravel banks, composed largely of fossils, chiefly calcareous sponges and polyzoa, resembling in appearance the Crag deposits of East Anglia. Brachiopods and echinoids are also numerous, but except for oysters and large nautiloids in the Red Gravel, mollusca are comparatively rare. 'The way in which the Sponge Gravels are overlapped confirms the impression that they were accumulated in pre-existing hollows, possibly excavated and probably at least scoured out by submarine currents. If the valleys were of subaerial origin, soil, gravel, or detritus might be expected, but none seems to exist. The abundance of derived nodules and fossils, especially in the pebble bed, suggests that the higher ground of Kimmeridge Clay between the valleys was being reduced by marine planation while the Sponge Gravels were accumulating in submerged depressions a little way off shore' (Arkell 1947*a*, p. 160). Elliott (1947) examined 500 specimens of the brachiopod *Gemmarcula aurea* and found that 84 per cent. were worn disconnected valves or mere pieces and 16 per cent. were whole and undamaged. To account for this seemingly anomalous mixture he pictured a turbulent marine environment with brachiopods and other sessile organisms living in the crevices of the sponge-banks; some were buried where they grew, others lost their anchorage and were pounded to bits by the currents. Later he abandoned this idea and regarded the whole as a current-accumulation (Elliott 1956). This view accords better with the absence of *Exogyra latissima, Gervillella sublanceolata, Yaadia nodosa*, and all the other heavy molluscs built for life in current-swept waters but not easily moved after death. Arkell believed that the sponge-banks were not of littoral origin but had accumulated in a clear, shallow, neritic sea, and he compared their ecological assemblage with that of the Inferior Oolite (*parkinsoni* Zone) of Shipton Gorge, Dorset. A much closer parallel is found in the 'gompholite' of Blangy, in the Ardennes of northern France, described long ago by Barrois (1878, pp. 248–57). Here, similar sponge- and polyzoa-gravels of Aptian age occupy the bottom of a channel in Silurian schists and quartzites.

Sowerby (1811) seems to have been the first to draw attention to the faunal peculiarities of the Faringdon Sponge Gravels, though many of the fossils were first described by Sharpe (1854), who thought the odd assemblage a Danian one. Meyer (1864*a*) replaced it correctly in the Lower Greensand. Hinde (1883) described and figured the sponges and Gregory (1899–1909) and Canu and Bassler (1926) dealt with the polyzoa, of which there are no less than thirty genera and sixty-two species. Almost as many foraminifera were listed by Davey (1905) and Wright (1905). The following are characteristic fossils of the Sponge Gravels, found chiefly in the Little Coxwell pit, which has contributed to almost every museum in the country:

Calcareous sponges: *Raphidonema farringdonense, R. macropora, R. porcatum, R. contortum, R. pustulatum, Corynella foraminosa, Synopella pulvinaria, Oculospongia dilatata, Elasmocoelia crassa, E. mantelli, Barroisia anastomosans, B. irregularis, B. clavata, Peronidella ramosa, P. gillieroni, P. prolifera.* Corals: *Smilotrochus austeni, Astrocoenia* sp. Echinoids: *Hyposalenia wrighti, H. lardyi, H. stellulata, Tetragramma rotulare, 'Cidaris' faringdonensis, 'C'. coxwellensis, Plagiochasma faringdonense, Goniopygus delphinensis.* Brachiopods: *Sellithyris coxwellensis, Cyrtothyris cyrta, C. uniplicata, C. cantabridgiensis, Praelongithyris praelongiforma, Gemmarcula aurea, Arenaciarcula fittoni, 'Ornithella' juddi, Cyclothyris latissima, 'Rhynchonella' depressa, Bifolium faringdonense.* Polyzoa: *Proboscina crassa, P. coarctata, Berenicea faringdonensis, B. (Reptomultisparsa) tenella, Reptoclausa hagenowi, Cellulipora spissa, Meliceritites cunningtoni, M. semiclausa, Siphodictyon gracile, S. irregulare, Petalopora cunningtoni, Reptomulticava fungiformis, Ceriopora faringdonensis, C. collis, C. dimorphocella, Heteropora clavata, Diaperoecia orbifera, Laterocavea dutempleana, Multigalea canui, Zonatula brydonei, Seminodicrescis nodosa, Stomatopora calypso, Tholopora virgulosa, T. thomasi, Tretocycloecia densa.* Lamellibranchs: *Lopha diluviana, Gryphaeostrea canaliculata, Exogyra conica.* Cephalopods: *Eutrephoceras sublaevigatum, Anglonautilus undulatus.*

The fauna also contains a species of *Burgundia* (R. F. Wise Coll., B.M.), the only known occurrence of a stromatoporoid in the Lower Greensand, and the whole assemblage is dated as the lower half of the *nutfieldensis* Zone (*subarcticum* Subzone) by rare *Parahoplites nutfieldensis* and *P. maximus* in the Red Gravel (L. Treacher, C. W. Wright, and R. V. Melville Coll.). Lamplugh's (1903) correlation of these deposits with the upper part of the *brunsvicensis*-beds of Speeton was based on belemnites misidentified as *B. speetonensis*, apparently worn examples of *Neohibolites ewaldi* (see Swinnerton 1955, p. xxxiii).

Excavations for a reservoir on Faringdon Folly, to the east of the town, exposed fossiliferous sands and pebbly sandstones, apparently belonging to the topmost of the four divisions of the Faringdon Lower Greensand recognized by Meyer (bed 4 of Arkell 1947). The sandstone, estimated to lie 50 feet or more above the Sponge Gravels, yielded to Mr. R. V. Melville and others a small suite of fossils, including *Parahoplites* cf. *nutfieldensis* and an allied form known also from Group XIV at Shanklin, the latter suggesting a position in the *cunningtoni* Subzone. The lamellibranchs *Ptychomya robinaldina* and *Isocyprina sedgwicki* and the gastropod *Brightonia turris* gen. et sp. nov. also occurred; the last two are not known elsewhere in the Southern Basin and link the locality with Potton and Upware.

South of Aylesbury, Buckinghamshire, near the northern border of the province, there are a few patches of ferruginous sands of dubious relationship. Some are unquestionably of Wealden age; others are probably vestiges of the Lower Greensand (Bishopstone Beds of Davies 1899), but the only place where marine fossils have been recorded is a pit, long filled in, south of the Bugle Inn, Hartwell. Here Morris (1867, p. 456) is said to have found *Exogyra latissima* and other lamellibranchs, together with derived blocks of Wealden sandstone.

To the south-west of Oxford, on Boars Hill and round Culham and Clifton Hampden, the Kimmeridge Clay is overlain by ferruginous pebbly sands, in parts much resembling the sands seen in the Faringdon reservoir excavations. Pringle (1926, p. 100) recorded a small fauna of molluscs and brachiopods, but no ammonites, from these sands (Toot Baldon Beds of Davies 1899). In the *Summary of Progress of the Geological Survey for 1900*, p. 120, cherty sandstone with marine fossils is recorded as having been found east of Marsh Baldon by J. H. Blake. The fossils were identified by E. T. Newton and included '*Ammonites* sp. Three fragments, one of which may be *A. nutfieldensis*, but is too imperfect for identification.' The report then goes on to say that '*Ammonites Deshayesi* and *Terebratula sella*' had been found in a roadside cutting at Toot Baldon by Professor Ramsey, Mr. Etheridge, and Mr. Hull during a tour of inspection about the year 1860 or 1861. None of these fossils has survived, though their recorded presence offers promise for future investigation.

Better evidence of the *nutfieldensis* Zone is afforded by the outliers around Calne and Devizes in Wiltshire. Here the Lower Greensand oversteps the Portland Beds on to faulted Kimmeridge Clay and Corallian. The most important outlier is at Seend, about 3½ miles west of Devizes, where the sands are so strongly impregnated with ferruginous matter that they were at one time worked for iron-ore. No fossils have been forthcoming from Seend for many years, but in the last century the sands produced a large fauna, now known largely by the Cunnington and Davey Collections in the Geological Survey and Oxford University Museums. The fauna is quite different from the sponge-polyzoa assemblage of Faringdon and is composed mainly of molluscs and brachiopods. A short list of fossils was published by Cunnington (1850), but the fauna was never studied systematically. Woods seems to have dealt with only a few of the lamellibranchs and many of the common forms (*Myoconcha delta* sp. nov., *Cryptochasma ovalis* gen. et sp. nov., *Pachythaerus tealli*, *Linearia* cf. *olea*) were either not mentioned or not described in his monograph. The following list is also incomplete, there being many forms too poor for determination:

Brachiopoda: *Gemmarcula aurea*, *Arenaciarcula fittoni*, *Oblongarcula oblonga*, '*Ornithella*' *juddi*, *Sellithyris coxwellensis*, *Cyclothyris latissima*, '*Rhynchonella*' *depressa*. Polyzoa: *Entalophora ramosissima*. Echinoidea: *Cidaris sp.* Lamellibranchia: *Arca dupiniana*, *Barbatia marullensis*, *Aptolinter aptiensis*, *Cryptochasma ovale* gen. et sp. nov., *Nuculana scapha*, *Nucula meyeri*, *Septifer sublineatus*, *Myoconcha delta* sp. nov., *Lopha diluviana*, *Panopea gurgitis*, *Senis wharburtoni*, *Linotrigonia* (*Oistotrigonia*) *upwarensis*, *Sphaera corrugata*, *Venilicardia sowerbyi*, *Nemocardium* (*Pratulum*) *ibbetsoni*, *Pachythaerus tealli* sp. nov., *Seendia saxoneti*, *Cardita upwarensis*, *Trapezicardita squamosa*, *Opis* (*Trigonopis*) *neocomiensis*, *Linearia* cf. *olea*, *Protodonax minutissimus*, *Lithophaga spp.*, *Chlamys robinaldina*, *Neithea quinquecostata*, *N. atava*, *Acesta longa*, *Pseudolimea faringdonensis*, *Toucasia lonsdalii*. Gastropoda: *Anchura* (*Perissoptera*) *robinaldina*, *Gyrodes genti*, *Conotomaria seendensis*, *Nerinea sp. nov.*, *Nerita sp. nov.*, *Scurria calyptraeformis*, *S. depressa*, *Acmaea formosa*, *Loxotoma neocomiense*. Cephalopoda: *Eutrephoceras sublaevigatum*, *Parahoplites nutfieldensis*, *P. cunningtoni* sp. nov., *P. spp. nov.*

Keeping (1883, pl. 51) mentions the occurrence of the fish *Sphaerodus neocomiensis* and various undetermined reptilian bones. Cunnington's 'small corals' are polyzoa. An interesting feature of the gastropod community is the dominance of limpets (*Scurria*, *Acmaea*, *Loxotoma*), the species of *Scurria* being endemic. Several of the lamellibranchs are characteristic Upware species (*Opis neocomiensis*, *Trapezicardita squamosa*, *Cardita upwarensis*); *Pachythaerus tealli* is found also at Potton; *Seendia saxoneti* and *Myoconcha delta* are known nowhere else in the Lower Greensand, and the genus *Protodonax* is a new record for Europe. Crypts of *Lithophaga* of unusually large size extend into the limestones of the Kimmeridge Clay. The whole assemblage is slightly later than the Faringdon Sponge Gravels and is on the same horizon as the Iron Sands of Pulborough, the Puttenham Beds of Surrey, and Group XIV of the Isle of Wight.

Ferruginous Sands similar to those at Seend were once exposed at Stock Orchard, south of Calne, and were found to contain a colony of the rudist lamellibranch *Toucasia lonsdalii*.

Mammillatum Zone. The remaining datable strata of Lower Greensand age in this region belong to the *mammillatum* Zone. They consist of green and brown, glauconitic and ferruginous loams, sometimes hardened into stone, and form the basement-beds of the Gault. Some of the sands running parallel with the outcrop of the Gault, such as the strip of red sand near Uffington, in the White Horse Vale, Berkshire, may be of earlier Albian age, but in the absence of fossils the question must be left open.

As early as 1836 Fitton (1836, p. 258) recorded a *mammillatum* Zone ammonite (*A. monile*) from Crockerton, in the Vale of Wardour, Wiltshire. The specimen is in the Geological Survey Museum and is *Douvilleiceras mammillatum*. No exposures of this zone exist at Crockerton today. Elsewhere in Wiltshire the *mammillatum* Zone has been found at Dinton, also in the Vale of Wardour, and at Dilton Marsh, near the north-west border of the county (Casey 1955*b*).

A well sunk north-east of the church at Dinton in 1890 gave the following (summarized) section:

		ft.	*in.*
Gault clay			
Gault basement beds	3. Hard grey ferruginous sandy rock; fossils . . .	5	8
	2. Reddish-brown sandstone with scattered pebbles, fossils, and fragments of wood	2	6
	1. Layer of small pebbles		6
Lower Greensand			

This was recorded by Jukes-Browne in 1891 and a further description of the section, with lists of fossils from the different beds, was published in 1900 (Jukes-Browne 1900, p. 228). Both Jukes-Browne and Reid (1903, p. 32) thought that the 'Gault' basement beds were younger than the *mammillatum* Zone, but re-examination of the fossils showed that they were referable to the *kitchini* Subzone, species of *Sonneratia*, *Inoceramus coptensis*, and other molluscs of early *mammillatum* age being included (Casey 1955*b*).

A section close to the middle of the old working face of the Bremeridge pit, near Dilton Marsh, north Wiltshire, was examined by Mr. G. A. Kellaway in 1943 and the following description is summarized from his notes:

		ft.	*in.*
Gault clay (weathered)	. . . .	5	6
Gault basement beds	2. Earthy and pebbly ironstone with septarian nodules and scattered limonitic ooliths, passing into . . .	3	0
	1. Sandy and ferruginous clays, dark bluish-grey, with pebbles and lumps of clay. A layer of re-sorted clay with broken *Ostrea delta* at base	2	6
Kimmeridge Clay	. . . .	12	0
Westbury Ironstone	. . . .	6	0

The sandy and ferruginous clay (bed 1) yielded a fauna very similar to that of Dinton, including poorly preserved *Sonneratia*, and from the overlying bed (bed 2) Mr. Kellaway obtained large arborescent polyzoa (*Ceriopora*) and portions of a gigantic species of *Douvilleiceras*, comparable with that found in the *regularis* Subzone of the Folkestone Beds of Folkestone and in the *kitchini* Subzone at Westerham (Casey 1955*b*, p. 233). It is concluded that the ferruginous basement beds of the Gault at Dinton and near Dilton Marsh are the correlatives of the *Sonneratia kitchini* band of Folkestone.

A considerable interval of time must have elapsed before the sea spread into the adjacent area of north Dorset, for several distinct faunal assemblages, such as that of the *floridum*, *raulinianus*, and *puzosianus* Subzones, existed between the period of deposition of the basal *mammillatum* Zone and the basal *dentatus* Zone, to which is now referred the base of the Albian at Okeford Fitzpaine, north Dorset. Here the Gault rests on Kimmeridge Clay and contains *Douvilleiceras inaequinodum* and species of *Hoplites* (Newton 1897; Spath 1925*a*, p. 75).

A few miles north-east of Okeford Fitzpaine a narrow band of glauconitic and ferruginous loam intervenes between the Gault and the Kimmeridge Clay, extending in the direction of Shaftesbury. These beds were first noted by Jukes-Browne (1891) and were subsequently termed Bedchester Sands by White (1923, pp. 42–44). No fossils have been found in them and they have been claimed variously as representatives of the Hythe Beds (White 1923) and of the Sandgate Beds (Kirkaldy 1939, p. 402). Their lithology and the way in which they run parallel with the Gault suggests that they are a continuation of the *mammillatum* Zone observed farther north.

A pebble-band separating the Gault and Kimmeridge Clays at Culham, Oxfordshire, has also been assigned to the *mammillatum* Zone (Treacher 1908, p. 549; Spath 1923*c*, p. 71; Pringle 1926, p. 101; Arkell 1947*a*, p. 170); but the evidence for this is spurious. The fine specimen of *Douvilleiceras mammillatum* figured by Spath from 'Culham' (Spath 1925*a*, pl. 5, fig. 1) is, in fact, Fitton's original '*Ammonites monile*' from Crockerton, Wiltshire, now preserved in the Geological Survey Museum (GSM Geol. Soc. Coll. 1713). The specimen of '*D. mammillatum*' which Pringle (1926, p. 102) said he had found in this bed, also in the Geological Survey Museum, is a derived Kimmeridgian *Pavlovia*. I have not seen the example of the zone ammonite found by White (Treacher 1908, p. 549), but its association with '*Ammonites beudanti* . . . of very large size' suggests the basal *dentatus* Zone, where *Beudanticeras laevigatum* reaches a diameter of 6 or 8 inches. Another example of '*Douvilleiceras mammillatum*' from Culham, in the Cunnington Collection in the British Museum, is too small for specific determination and may be of either *mammillatum* or *dentatus* age. Its mode of preservation, with parts of the nacreous shell attached, does not indicate the pebble-bed but the overlying clays, from which a rich fauna of early *dentatus* age has been obtained.

NORTHERN BASIN

The Lower Greensand deposits north of the London Ridge were laid down in a different basin from the typical Lower Greensand of south-east England and the succession is relatively thin and incomplete. In Lincolnshire and Norfolk the formation succeeds a marine facies of the Neocomian, but when it extends southwards into Cambridgeshire, Bedfordshire, and north-east Buckinghamshire and northwards to the fringe of Yorkshire it comes to rest on an eroded surface of Jurassic age. In the southern part of the Basin deposition seems to have been influenced by movements along axes of Charnian trend (Rastall 1919; 1925). The Northern Basin is the sole source in the Lower Greensand of the *bodei* fauna, at the very bottom of the Aptian, which occurs as a derived or remanié element, generally in a basal nodule-bed.

Cambridge–Bedford Province

North of Aylesbury there is an interval of 10 miles before the Lower Greensand reappears in Bedfordshire, forming a thickness of 200 feet of predominantly yellow sands in the Woburn and Leighton Buzzard districts. These deposits are known as the Woburn or Potton Sands and they have long been famed as a source of derived Jurassic fossils and a large indigenous fauna of brachiopods, lamellibranchs, and sponges, best known from the old 'coprolite' workings at Little Brickhill and Potton. A similar mixture of derived and native fossils was found in the Lower Greensand of Upware, Cambridgeshire. Most of the fossils were obtained as a by-product of 'coprolite' extraction, being picked out of the siftings by the workfolk. The classic exposures disappeared with the decline in the home phosphate industry towards the end of the last century, but we are fortunate in having contemporary accounts by Teall (1875) and Keeping (1883) of Cambridge. Loss of the Potton and Upware exposures was counterbalanced by the discovery of new fossiliferous horizons at the top of the sands around Leighton Buzzard (Lamplugh and Walker 1903).

At Little Brickhill, 2½ miles east of Bletchley, Buckinghamshire, 30 feet of sand with scattered phosphatic nodules was seen resting on Oxford Clay; the lower part consisted of greenish-grey shelly sand, in places cemented into layers like Bargate Stone (Teall 1875, p. 43). Indigenous fossils were obtained only from the lower sands and comprised a few long-ranging lamellibranchs, some of the calcareous sponges and echinoids found at Faringdon (*Rhaphidonema porcatum*, *Barroisia anastomosans*, *B. clavata*, *Peronidella ramosa*, *Hyposalenia wrighti*, *Tetragramma rotulare*) and above all brachiopoda. The following list bears out Keeping's (1883, p. 21) comment: 'Brickhill was the metropolis of the Brachiopoda, in Cretaceous times.' *Rhombothyris extensa*, *R. microtrema*, *R. conica*, *Platythyris comptonensis*, *P. minor*, *Sellithyris upwarensis*, *Cyrtothyris cyrta*, *C. uniplicata*, *C. cantabridgiensis*, *C. seeleyi*, *C. dallasi*, *Praelongithyris praelongiforma*, *P. lankesteri*, '*Ornithella*' *juddi*, '*O.*' *pseudojurensis*, '*O.*' *tamarindus*, '*O.*' *wanklyni*, *Zeilleria woodwardi*, *Kingena rhomboidalis*, *Gemmarcula aurea*, *Arenaciarcula fittoni*, *Oblongarcula oblonga*, *Trifidarcula trifida*, *Terebratella keepingi*, *T. davidsoni*, *Terebratulina elongata*, *Cyclothryris latissima*, *Lamellirhynchia* cf. *caseyi*, '*Rhynchonella*' *upwarensis*, '*R.*' *cantabridgiensis*, '*R.*' *antidichotoma*, '*R.*' *depressa*. The hexactinellid sponge *Plocoscyphia pertusa*, the echinoid *Salenia hieroglyphica*, and a few polyzoa were also found.

At Potton, near Sandy, Bedfordshire, indigenous fossils occurred in ferruginous layers and included the gastropod *Bathrotomaria ferruginea*, the lamellibranchs *Isocyprina sedgwicki*, *Goniochasma dallasi*, *Pterotrigonia mantelli*, *Chlamys robinaldina*, *Exogyra latissima*, and several species of the brachiopod *Cyrtothyris*. Derived material in the nodules near the base comprised many Upper Jurassic fossils, blocks of Neocomian sandstone, bones of *Iguanodon*, and the Lower Aptian ammonites *Prodeshayesites fissicostatus* and *Australiceras gigas*.

Cuttings for the London–Yorkshire Motorway half a mile north 45° east of All Saints Church, Ridgmont, Bedfordshire, revealed coarse yellow sand resting on Ampthill Clay. At the base of the sands was a band of pebbles and nodules, 18 inches thick, crowded with rolled *Pavlovia*, *Hartwellia*, and other fossils derived from the Hartwell Clay. In the same bed, probably having used the pebbles and nodules for anchorage, were indigenous brachiopoda, including *Platythyris comptonensis*.

An important Aptian flora has been obtained from the Woburn Sands, described from driftwood and cones found mostly in the basal nodule-beds and in a band of fuller's earth several feet above (Carruthers 1866–70; Stopes 1912, 1915). At Potton and Sandy the nodule-bed has yielded the cones *Pinostrobus cylindroides*, *P. pottoniensis*, *Kaidacarpum minus*, and *Cycadeostrobus walkeri*, coniferous wood *Cedroxylon pottoniense*, the 'tree-fern' *Tempskya erosa*, and the cycadophyte *Bennettites inclusus*. Some of these have been regarded, without real evidence, as Wealden derivatives. Woburn itself is the source of the conifers *Pityoxylon woodwardi*, *Cupressinoxylon hortii*, *Taxoxylon anglicum*, *Podocarpoxylon woburnense*, *P. bedfordense*, and the angiosperms *Woburnia porosa* and *Sabulia scottii*. At Leighton Buzzard, probably from the 'Silver Sands', were obtained the types of the cycadophytes *Cycadeoidea yatesi* (= *Yatesia morrisi*) and *C. buzzardensis*.

The fossiliferous beds at the junction of the Woburn Sands and the Gault near Leighton Buzzard have been described by Lamplugh and Walker (1903), Kitchin and Pringle (1921; 1922*b*), Lamplugh (1922), Wright and Wright (1947), and Hancock (1958). The beds show rapid lateral variation, as pointed out by Toombs (1935); of the three principal exposures now available two show the familiar facies of glauconitic loams and phosphatic nodules, and the third (Munday's Hill) displays the lenticles of fossiliferous limestone (Shenley Limestone) which first attracted attention to this locality. For many years a controversy raged between Lamplugh and his Survey colleagues, Kitchin and Pringle, as to whether this limestone was in place, the latter maintaining that it was of Cenomanian age and, together with the Gault, had been turned upside-down by glacial action. Lamplugh's straightforward reading of the section now commands a more general acceptance than it did in his lifetime.[1] In Arnold's pit (formerly Pratt's pit), Billington Crossing, south-east of Leighton Buzzard, Wright and Wright made out the following sequence:

Gault–Lower Greensand Junction-Beds at Arnold's Pit, Billington Crossing, Leighton Buzzard

	ft.	*in.*
Grey clays of *dentatus–spathi* Subzone		
Sandy-brownish clay with four bands of phosphatic nodules, as under:		
Band IV (4 ft. 6 in. above base of clay). Scattered nodules less pebbly and smoother than those below.		
Band III (3 ft. 4 in. to 3 ft. 10 in. above base of clay). Sparse, irregular nodules, perhaps lying in two beds.		
Band II (2 ft. to 2 ft. 6 in. above base of clay). Abundant, irregular, round, elongated or flattened nodules, blackish inside with a grey outer surface studded with pebbles.		
Band I (9 in. to 1 ft. above base of clay). Fairly smooth, dark-brown nodules with pale-brown crusts.	5	0
Thin bed of indurated pebbly sand, with fragments of carstone, the whole sometimes phosphatized.		
(Sharp junction)		
Current-bedded 'Silver Sands'.		

Band I contains a *regularis* Subzone fauna with the ammonites *Leymeriella regularis*, *L. tardefurcata*, *L. rudis*, *L. consueta*, *Anadesmoceras sp. nov.*, the lamellibranchs *Thetironia minor*, *Cucullaea glabra*, *Pseudocardia tenuicosta*, and the gastropods *Claviscala clementina*, *Gyrodes genti*, *Leptomaria billingtonensis*, and many other small molluscs. Band II is a condensed deposit in which species of both the *regularis* Subzone and the *kitchini* Subzone of the *mammillatum* Zone occur side by side; the former horizon is indicated by *L. tardefurcata*, *L. regularis*, *L. renascens*, *L. diabolus*, *L. consueta*, *L. pseudoregularis*, *Anadesmoceras baylei*, *A. subbaylei*, *Aconeceras sp. nov.*, and *Eogaudryceras shimizui*; the latter by *D. mammillatum*, *B. newtoni*, and *S. kitchini*. Associated with these are many of the molluscs commonly found on these horizons in the south: *Inoceramus salomoni*, *I. coptensis*, *Panopea gurgitis*, *Cucullaea glabra*, *Thetironia minor*, *Resatrix* (*Dosiniopsella*) *vibrayeana*, *Pseudocardia tenuicosta*, *Entolium orbiculare*, *Neithea quinquecostata*, *Gyrodes genti*, *Leptomaria gibbsi*, *Semisolarium monili-*

[1] For the sake of historical accuracy it must be pointed out that the debate did *not* end with the discovery of *Leymeriella* in the limestone, for even Spath (1925*d*) was prepared to admit that it may have been derived. It was the presence of Lower Gault ammonites in the lower part of the clays above the limestone, showing the succession to be normal, that put the matter to rest (Spath 1930*b*, p. 271).

ferum, *Tessarolax retusum*, &c. Band III is another condensed horizon, containing elements of the *kitchini* Subzone and the basal part of the *dentatus* Zone. Here are found *D. mammillatum*, *D. monile*, *B. newtoni*, *S. kitchini*, *S. perinflata*, *S. spp. nov.*, apparently mixed with *Hoplites* and *Isohoplites*. Specimens of *Protanisoceras acteon* and *Cleoniceras floridum* picked up loose suggest that there is also a sparse representation of the *floridum* Subzone in this band. Wright and Wright believed that this band may contain two distinct concentrations of nodules, but it has not been possible to sort out the faunas stratigraphically. Band IV is of early *dentatus* age.

The principal fact that has emerged from restudy of the Leighton Buzzard ammonites is that only the lower part of the *mammillatum* Zone is present between the *tardefurcata* Zone and the *dentatus* Zone. Although *D. mammillatum* occurs in both Bands II and III all the associated ammonites of *mammillatum* age belong to the *kitchini* or *floridum* Subzones. The absence of the *raulinianus* and *puzosianus* Subzones with their distinctive assemblages of *Otohoplites*, *Protohoplites*, *Hemisonneratia*, and *Pseudosonneratia* is surprising; in the south the *puzosianus* Subzone is a transgressive deposit and is the last to disappear on the crests of the *regularis–mammillatum* troughs. The fact that the *mammillatum* Zone sequence is here out of phase with that of the Southern Basin may have some tectonic meaning.

Chamberlain Barn pit, on the north side of the town, shows a similar succession to that of Billington Crossing but exact correlation of the nodule-bands is difficult. The basal pebble-bed is cemented into a conspicuous carstone breccia in which lumps of Shenley Limestone are found occasionally, proving that the limestone was formed contemporaneously with the breccia or before it. Lenticular masses of iron-cemented sand occur in the underlying 'Silver Sands'; they have yielded pieces of wood and, very rarely, lamellibranchs (*Acesta longa*); they have already been mentioned as the probable source of *Cycadeoidea*.

North of Chamberlain Barn, on the lower slopes of Shenley Hill, the phosphatic-nodule facies of the *regularis* Subzone is replaced by the famous Shenley Limestone, at present exposed only in the south-west corner of Munday's Hill pit. The limestone occurs in lenticles up to 2 feet thick and several yards across and is remarkably varied both in lithology and in fossil content. Sandy or pebbly, yellow or pink, crowded with brachiopods or lamellibranchs, each lenticle has a character of its own. Laterally they are replaced by carstone breccia, the whole resting on a guttered surface of phosphatized iron-grit. The fauna of the limestone is unique and remarkable. Not only does it contain a rich and distinctive set of brachiopods, but its assemblage of echinoids and crustacea is also unmatched elsewhere. Hawkins (1921*a*; 1921*b*) studied the echinoidea and was struck by the abundance of *Pyrina*; he thought that this probably indicated littoral conditions since *Echinoneus*, the modern representative of the family, inhabits tidal flats. Apparently the brachiopods and other sessile benthos grew on the craggy surface of the iron-grit, an environment too rough and shallow for ammonites, whose shells are exceedingly rare in the limestone, though characteristic of the nodules a few hundred yards away. Brachiopods are well preserved and constitute the bulk of individuals, the commonest being '*Terebratula*' *capillata*, which in some lenticles may make up 90 per cent. of the fossils (Hancock 1958, p. 39). The following list is by no means complete but includes the commoner and more important forms:

Brachiopods: '*Terebratula*' *capillata*, '*T.*' *dutempleana*, '*T.*' *gigantea*, *Rectithyris depressa*, *R. shenleyensis*, *Terebratulina triangularis*, *Zeilleria convexiformis*, *Modestella sp. nov.*, *Magas latestriata*, *M. orthiformis*, *Terebrirostra arduennensis*, *Gemmarcula menardi*, *Id.* var. *pterygotos*, *Kingena lima*, *K. arenosa*, *K. newtoni*, '*Rhynchonella*' *shenleyensis*, '*R.*' *grasiana*, '*R.*' *lineolata*, '*R.*' *mirabilis*, '*R.*' *leightonensis*, '*R.*' *dimidiata*, '*R.*' *antidichotoma*. Lamellibranchs: *Septifer sublineatus*, *Modiolus reversus*, *Oxytoma pectinatum*, *Chlamys robinaldina*, *Neithea quinquecostata*, *Plagiostoma globosum*, *Acesta longa*, *Limatula sabulosa* sp. nov., *Plicatula inflata*. Gastropods: *Claviscala clementina*, *Confusiscala dupiniana*, *Bathrotomaria leightonensis*, *Tectus* cf. *huoti*, *Eucycloscala mulleti*, *Sipho gaultinus*, *Neptunella* cf. *espaillaci*. Ammonites: *Leymeriella tardefurcata*, *L. regularis*, *Aconeceras sp. nov.* Echinoids: *Pyrina desmoulinsii*, *Conulopyrina anomala*, *Hyposalenia studeri*, *Salenia rugosa*, *Toxaster* *murchisonianus, Nucleolites lacunosus, Catopygus columbarius, Holaster* (*Labrotaxis*) *cantianus.* Crinoids: *Isocrinus fittoni, Torynocrinus sp.* Crustaceans: *Goniodromites scarabaeus, Cyphonotus incertus, Diaulax carteriana, Enoploclytia tuberculata, Cretiscalpellum unguis, Pycnolepas rigida.*

Scarcely less remarkable than the Shenley Limestone are the wedges of greensand seen by Lamplugh (1922, pp. 10, 49) to be interposed locally between the carstone breccia and the Gault. This greensand does not seem to have been exposed in recent years, though a set of specimens are in the Geological Survey Museum. It is full of phosphatic fragments, small pebbles, guards of the belemnite *Neohibolites minimus*, and sharks' teeth (*Lamna appendiculata, Scapanorhynchus subulatus, S. raphiodon*? and *Apateodus*?). The oysters *Ostrea vesiculosa* and *Gryphaeostrea canaliculata, Serpula antiquata*, cirripede valves, and a nautiloid were also recorded by Lamplugh. The Red Clay immediately above the Shenley Limestone includes lenticles crowded with columnals of *Isocrinus* and valves of the cirripedes *Pycnolepas rigida* and *Cretiscalpellum unguis*; its zonal position is unknown.

Since the statement that the Shenley Limestone is known only at Shenley Hill has been repeated (Hancock 1958), it is necessary to draw attention again to the old pit a quarter of a mile north of Long Crendon, Buckinghamshire, where 'lumps of calcareous stone' were found between the base of the Gault and the Purbeck Beds. Both in its fauna and lithological characters this stone is indistinguishable from the Shenley Limestone, as pointed out by Lamplugh (1922, p. 41). Although the occurrence was discounted by Kitchin and Pringle (1922*b*), anyone who examines the specimens of this stone in the Geological Survey Museum will surely admit that an outlier of Shenley Limestone exists north of Long Crendon. The former extension of the *regularis* Subzone some 12 miles south-west of Leighton Buzzard is thus indicated.

At Upware, near Cambridge, a few feet of Lower Greensand were found banked against a folded ridge of Kimmeridge Clay and Corallian limestone (Keeping 1883, p. 4). Supposed indigenous fossils occurred in two seams of nodules and pebbles at the base, mollusca mostly in the lower seam, brachiopoda mostly in the upper. The fauna included a large series of brachiopoda practically duplicating that of Brickhill, some calcareous sponges found also at Faringdon (*Rhaphidonema porcatum, R. macropora, Barroisia anastomosans, B. clavata*, &c.), and polyzoa. Mollusca were much better represented than at Brickhill, Potton, or Faringdon: the distinctive forms being the lamellibranchs *Nucula meyeri, Barbatia marullensis, Eonavicula carteroni, Cucullaea cornueliana, Cryptochasma ovale* gen. et sp. nov., *Glycymeris* (*Glycymerita*) *sublaevis, Trapezicardita squamosa, T. arcadiformis, Opis neocomiensis, Astarte cantabrigiensis, Eriphyla upwarensis, Isocyprina sedgwicki*, and the gastropods *Pleurotomaria campichei, Brightonia turris* gen. et sp. nov., *Gymnocerithium tumidum, Tessarolax gardneri, Tridactylus walkeri, Nododelphinula reedi, Eucyclus upwarensis, Ooliticia cantabrigensis*, and *O. varicosa*. The ammonites, now in the Sedgwick Museum, are redetermined as follows: *Colombiceras sp. nov.* cf. *tobleri* (? *nutfieldensis* Zone), ? *Cheloniceras crassum* var. *nov., Tropaeum keepingi* (? *bowerbanki* Zone), *Deshayesites multicostatus, D.* cf. *consobrinoides, Toxoceratoides* cf. *royerianus* (*deshayesi* Zone, *parinodum* Subzone), *Deshayesites* cf. *forbesi* (? *forbesi* Zone), *Prodeshayesites fissicostatus, P. spp. nov.* (*fissicostatus* Zone, *bodei* Subzone).

In Spath's zonal table (1923*b*, p. 148) the Upware deposit is shown as spanning the '*consobrinoides*' and '*hillsi*' Subzones (= *deshayesi* Zone of the present classification) and as equivalent to the Hythe Beds of East Kent. In fact there is a much wider zonal representation, as indicated above. The vast majority of the ammonites are of Lower Aptian age; the only exception is a single example of *Colombiceras*, which certainly belongs to the Upper Aptian, probably the *nutfieldensis* Zone. Both this and the unique *Tropaeum keepingi* have portions of the shell preserved in calcite and have a different aspect from the rest of the assemblage. Whether any of them are truly indigenous is difficult to say. At all events, the Lower Greensand of Upware, as shown by its ammonites, is an epitomized version of the greater part of the

Aptian stage. Some of the other mollusca (*Cryptochasma*, *Isocyprina*, *Opis*, *Brightonia*) are known elsewhere in the Lower Greensand only in the *cunningtoni* Subzone.

Beyond Upware and Ely the Lower Greensand is lost under the Fens. Borings show it dwindling almost to vanishing point a few miles north of Ely.

Lincolnshire–Norfolk Province

In Lincolnshire the Lower Greensand crops out in a narrow strip running parallel to the Chalk south-eastwards from the Humber to the southern end of the Wolds. It consists of a few feet of ferruginous sand and grit (Carstone) overlying the Neocomian and is in turn overlapped by the Red Chalk, a facies of the Gault peculiar to the eastern border of the Northern Basin. Its underground extension is proved by borings at Skegness (Woodward and others 1904, pp. 155–9). North of the Humber, in east Yorkshire, it oversteps the Neocomian and becomes a discontinuous deposit of variable thickness, apparently filling shallow depressions in an erosion surface. It may be seen, only a few inches thick, at Goodmanham, about a mile north-east of Market Weighton, resting on Lower Lias (Boer, Neale, and Penny 1958, p. 178). Strahan (1886) studied the Lincolnshire Carstone and showed that earlier views on its unconformable relations with the Red Chalk (Judd 1867; 1870) were incorrect, the junction being in fact gradational. Although there is no doubt that in the north there is a plane of erosion at the base of the Carstone, we owe to Swinnerton (1935) the discovery that at the southern end of the Lincolnshire Wolds the succession is more complete. In this area the Carstone is underlain by a few feet of grey and yellow marls (Sutterby Marl), first detected in borings at Alford and Maltby-le-Marsh and subsequently proved at outcrop east of the hamlet of Sutterby, about 2½ miles north-west of Fordington.

A rich cephalopod fauna was obtained from the Sutterby Marl of Sutterby, including ammonites identified as *Deshayesites fissicostatus*, *D.* aff. *laeviusculus*, *D. multicostatus*, *Aconeceras nisoides*, *A. sp.*, *Cheloniceras*, and *Tonohamites*? and numerous belemnites. While the belemnites occurred throughout the whole thickness of the marls, the ammonites were almost entirely restricted to a phosphatic nodule layer near the base. On the basis of the ammonite determinations the phosphate layer was assigned to the *bodei* Subzone, the base of the Aptian as here understood (Swinnerton 1935, pp. 24–25). Elsewhere (Swinnerton 1937, p. xxix) the Sutterby Marl has been equated with the *bodei* Subzone.

Through the kindness of Professor H. H. Swinnerton I have been able to examine his collection of Sutterby Marl ammonites. They are determined as follows: (1) phosphatic nodule band, *Aconeceras nisoides*, *Sanmartinoceras* (*Theganeceras*) cf. *falcatum*, *Prodeshayesites fissicostatus*, *P.* aff. *bodei*, *P. laeviusculus*?, *P. spp. nov.*, *Deshayesites* cf. *deshayesi*, *D. multicostatus*, *Dufrenoyia furcata*, *D. transitoria*, (2) crushed in the marl, *Colombiceras sp.*, *Tropaeum*? *sp.*

The ammonites in the phosphatic nodule bed belong to three different zones of the Lower Aptian; the species of *Prodeshayesites*, and possibly the aconeceratids, represent the *bodei* Subzone of the *fissicostatus* Zone, at the bottom of the Aptian; the *Deshayesites* belong to the lower half of the *deshayesi* Zone (*parinodum* Subzone); while the species of *Dufrenoyia* indicate the *bowerbanki* Zone, the top zone of the Lower Aptian. The last may include only the Subzone of *Dufrenoyia transitoria* (= *Deshayesites* aff. *laeviusculus* of Swinnerton). The ammonites crushed in the marls, presumably part of the indigenous fauna, include only one form that is generically determinable. This is a species of *Colombiceras*, a genus diagnostic of the Upper Aptian, and its occurrence is of great interest since the only other British *Colombiceras* known is the Upware specimen mentioned on an earlier page. There is, in fact, a very close agreement between the ammonite horizons of the Sutterby Marl and those of the Lower Greensand of Upware.

It is now apparent that the phosphatic nodule bed at the base of the Sutterby Marl is a highly condensed remanié and that the Sutterby Marl itself is of Upper Aptian age. This explains some anomalies in the belemnite fauna. Discussing the occurrence of *Neohibolites ewaldi*, the dominant belemnite in the Sutterby Marl, Swinnerton observed that at Speeton and in north Germany the species characterized strata *above* the *bodei* Subzone, only rare examples of *N.* cf. *ewaldi* having been recorded by Stolley from the *bodei* Subzone itself. From the association of *N. ewaldi* with ammonites of this subzone in the Sutterby Marl, Swinnerton concluded that faunal failure was probably responsible for the absence of this belemnite from the *bodei* Subzone of the Speeton and north German successions. Now that the *bodei* ammonites in the Sutterby Marl are known to be derived the discrepancy in the distribution of the belemnites disappears.

The plane of erosion which in the country to the north lies at the base of the Carstone is here present at the base of the Sutterby Marl. Rolled fragments of *Prodeshayesites* have been found in the Carstone of the north and central Wolds, but the only other locality in the Province that has yielded Aptian ammonites in numbers is Hunstanton, Norfolk.

The existence of a phosphatic nodule-bed full of ammonites at the base of the Carstone exposed on the foreshore at Hunstanton, Norfolk, has long been known and lists of fossils from this bed have been given by Wiltshire (1869) and Keeping (1883). Keeping was of the opinion that these fossils were derived, but this was denied by Lamplugh (1899, p. 142), who considered that the fauna was on its proper horizon. Spath (1930*a*, p. 422) thought that it contained ammonites of several horizons ranging from the *bodei* Subzone to the beginning of the Upper Aptian. Examination of all available collections of Hunstanton Carstone ammonites, supplemented by my own field work, discloses that the assemblage is composed of two faunas only, both Lower Aptian in age. The faunal list is as follows: *bowerbanki* Zone (*transitoria* Subzone), *Tropaeum bowerbanki*, *Id.*, var. *densistriatum*, *T. drewi*, *T. sp. indet.*, *Australiceras gigas*, *Tonohamites* (?) *sp. nov.*, *Cheloniceras* (*Ch.*) *cornuelianum*, *Ch.* (*Ch.*) *crassum*, *Id.*, var. *nov.*, *Ch.* (*Ch.*) *spp. nov.*, *Dufrenoyia furcata*, *D. truncata*, *D. transitoria* sp. nov., *D. sp. nov. fissicostatus* Zone (*bodei* Subzone), *Ancyloceras* cf. *varians*, *Prodeshayesites fissicostatus*, *P. bodei*, *P. laeviusculus*, *P. spp. nov.*

Species of *Prodeshayesites*, chiefly *P. fissicostatus* ('*A. deshayesi*' of early authors), make up about 90 per cent. of the fauna. Fossils other than ammonites are rare, though the lamellibranch *Mulletia mulleti* has been found. The 'peculiar dark grit' mentioned by Keeping from Hunstanton and which Kirkaldy (1939, p. 408) describes as occurring as derived blocks in the base of the Carstone are nodules from the underlying Snettisham Clay and contain Barremian ammonites of the genus *Paracrioceras* ('*Hamites* or *Ancyloceras*, small species with a double row of spines along the back', Keeping 1883, p. 33).

The only other ammonitiferous deposits of Lower Greensand age in Norfolk occur at West Dereham, between Stoke Ferry and Downham, at the southern extremity of the outcrop. Here old phosphate workings at the junction of the Gault produced a large fauna in the last century. The beds were fully described by Teall (1875) and Whitaker, Skertchley, and Jukes-Browne (1893). *Douvilleiceras mammillatum*, *Sonneratia kitchini*, *Hamites sp. nov.*, and other forms characteristic of the *kitchini* Subzone of the *mammillatum* Zone were found in the phosphatic nodules. The representation of the *kitchini* Subzone to the exclusion of the higher parts of the *mammillatum* Zone compares with the Leighton Buzzard sequence.

Neither in Lincolnshire nor in Norfolk has the Carstone yielded indigenous ammonites, though the way in which it passes up into the Red Chalk suggests that it is of Albian age. I agree with Versey and Carter that it is probably represented at Speeton by the greensand seam with phosphatic nodules and *Leymeriella* (Bed A 4) (Versey and Carter 1926).

PALAEONTOLOGY

PLANTAE

The Lower Greensand flora, first described as a unit by Stopes (1915), contains one of the world's earliest assemblage of angiosperms or flowering plants. In a public broadcast entitled 'The mystery of flowering plants' (reproduced in *The Listener*) Professor T. M. Harris called in question the authenticity of the angiosperms as Lower Greensand fossils (Harris 1956), mentioning specifically those from the Woburn Sands of Bedfordshire. Harris's scepticism is justified in so far as these plant-species are all based on old museum specimens, some inadequately labelled, but whatever problems their presence in the Lower Greensand poses to the palaeobotanists, the assumption that they are spurious raises questions even more difficult to answer. The following are my notes on the type specimens of the woods in question. With the exception of that of *Hythia elgari*, all are in the British Museum (Natural History).

Aptiana radiata Stopes. Labelled 'Lower Greensand, ? Luccomb Chine'. Matrix coarse glauconitic sand with bits of whitish phosphate, absolutely typical of the Luccomb Chine plant-bed near the base of the Sandrock. Parts of the 'Sulphur Band', at the top of the Lower Greensand at Folkestone, produce a similar lithology. Both horizons are replete with fossil wood.

Cantia arborescens Stopes. Sand from one of the boreholes in the specimen agrees with that of the Folkestone Beds of Ightham, Kent, the stated provenance of the specimen.

Hythia elgari Stopes. The type block, in the Maidstone Museum, was examined by me some years ago before I was aware of any doubts about its authenticity. From its matrix I had then accepted it as being correctly labelled as from the Hythe Beds of Maidstone. This is now reaffirmed from examination of a section of the specimen in the British Museum.

Woburnia porosa Stopes and *Sabulia scotti* Stopes. Both said to be from the Lower Greensand of Woburn. No matrix or adherent grains to check.

These observations offer no support for the assumption that the specimens did not originate in the Lower Greensand. Moreover, it is difficult to believe that two museums could both have obtained undescribed fossil angiosperm wood in various Lower Greensand-type matrices and have made the same blunder in labelling them.

Phylum COELENTERATA

Class HYDROZOA

Family MILLEPORIDAE

Genus LONSDA de Laubenfels 1955

Lonsda contortuplicata (Lonsdale)

Small calcareous growths with microscopic spongiform surface were described from the Lower Greensand of Atherfield by Lonsdale (1849, pp. 55–66, pl. 4, figs. 1–4) as a new genus and species of sponge ('Amorphozoa'), *Conis contortuplicata*. The generic name *Conis* having been used previously by Brandt in 1835, de Laubenfels (1955, pp. E86, 94) replaced it by *Lonsda* and treated the organism as a hyalosponge of uncertain affinities. Sections cut from one of Lonsdale's syntypes (GSM Geol. Soc. Coll. 1968) were examined by Dr. Kenneth Oakley, who reported (*in litt.* 16.1.48) that the organism is not a sponge but a hydrozoan similar to *Millepora lobata* Roemer from the

Neocomian of north Germany. According to Boschma (1956, p. F94) modern species of *Millepora* are found commonly on coral reefs, generally at depths not exceeding 30 metres, which seems to be correlated with dependence of the colonies on symbiotic unicellular algae that need light for their processes of assimilation. *Lonsda contortuplicata* occurs in the Upper Perna Bed at Atherfield and Sandown, where the coral *Holocystis elegans* is also found in great numbers.

Phylum POLYZOA

Class GYMNOLAEMATA

Family ASCODICTYIDAE

Genus GRAYSONIA Stephenson 1952

In *Graysonia* the zoarium is represented by a compound system of tubular stolons and vesicles embedded in the shells of marine molluscs, comparable with that of the Palaeozoic *Bascomella*. The genus is monotypic, the type species being *Graysonia bergquisti* Stephenson of the Cenomanian of Texas. A similar organism is found in the shells of *Exogyra* in the Folkestone Beds, though there seems to be no previous description of it in British literature.

Graysonia anglica sp. nov.

Plate 79, figs. 1, 2

Holotype. GSM 98600, Folkestone Beds, *regularis* Subzone (bed 5), Wrecclesham, Surrey (Author's Coll.).

Diagnosis. Similar in size and form to *G. bergquisti* (Stephenson 1952, p. 53, pl. 9, figs. 2–6, pl. 10, figs. 27, 28), but stolons less arched and more frequently branching.

Plate 79, fig. 2 illustrates the typical mode of occurrence of the stolon-system of *Graysonia anglica* in *Exogyra*. The holotype is part of the phosphatic infilling of an *Exogyra* shell that was subsequently dissolved away, leaving *Graysonia* in relief. This specimen shows a meshwork of stolons, a few widely scattered vesicles, and part of another organ, possibly the zoecium. The last is a thin-walled tube or sac, rising above the stolon-bearing surface, about 6 mm. in diameter and with an incomplete length of 12 mm. It is roughly elliptical in cross-section, bent about the middle, and presents an irregular blistered surface covered with microscopic parallel striations. Stolons communicate with it at the base. Zoecia have not been described in this primarily Palaeozoic family and I know of no other structure with which it could be compared.

Phylum BRACHIOPODA

Class ARTICULATA

Family ZEILLERIIDAE

Genus MODESTELLA E. Owen nov.

Type species. *Modestella modesta* gen. et sp. nov., Lower Albian, southern England.

Diagnosis. Small biconvex zeilleriids of terebratuloid aspect. Anterior commissure rectimarginate, ligate, or strangulate. Test thin, finely punctate. A shallow median sulcus between faint ridges in each valve. Beak suberect; beak-ridges sharp; foramen large, mesothyrid; deltidial plates conjunct, concave. Hinge-plates fused; hinge teeth wedge-shaped, supported by strong convergent dental lamellae. No cardinal process. Septalium acute, angular, forming a V-shaped hinge trough which is supported by a strong brachial septum extending two-thirds the valve-length. Crural bases and zeilleriform brachial loop given off dorsally.

Modestella modesta E. Owen gen. et sp. nov.

Plate 83, fig. 6*a–c*

1874 *Terebratula moutoniana* Price, p. 140 (*non T. moutoniana* d'Orbigny).

Holotype. GSM Zk 4733, Folkestone Beds, main *mammillatum* bed, Copt Point, Folkestone, Kent (Author's Coll.).

Diagnosis. *Modestella* about 12 mm. long, 10 mm. wide, and 7 mm. thick. Outline of pentagonal tendency; anterior commissure strangulate; interarea broad, slightly concave; foramen subcircular; hinge-margin subterebratulid; growth-lines prominent.

The name *Modestella* is proposed for a group of small zeilleriids found in the Lower Albian of southern England. The group is under investigation by Mr. E. Owen, from whose notes I have been permitted to take the above diagnoses. Clusters of *M. modesta* occur in the matrix of the main *mammillatum* bed nodules at Copt Point and may represent the fossilization more or less *in situ* of colonies that grew on the nodules. Isolated internal moulds are found sporadically throughout the *mammillatum* Zone of Kent and an allied species occurs in the Shenley Limestone.

Family TEREBRATELLIDAE

Genus TEREBRIROSTRA d'Orbigny 1847

Terebrirostra arduennensis d'Orbigny

This brachiopod was described by d'Orbigny (1847, pl. 519, figs. 6–10) from the Albian of Grandpré (Ardennes) and was listed by Barrois (1878, p. 275) as a fossil of the Ardennes '*mammillatum* Zone', which I have shown (Casey 1957) to include not only the restricted *mammillatum* Zone of southern England but also the underlying *regularis* Subzone of the *tardefurcata* Zone. Middlemiss (1959, p. 140) quotes it as a Lower Aptian form. Corroy (1925, p. 295) described it as an Albian form which Peron had recorded from the Upper Aptian of Grandpré. Admittedly, the fauna listed by Corroy has been regarded as Aptian since the time of Barrois, but for many years now

EXPLANATION OF PLATE 79

Figures natural size unless otherwise stated.

Figs. 1–2. *Graysonia anglica* sp. nov., Folkestone Beds (*regularis* Subzone). 1, Holotype, phosphatized infilling of *Exogyra* shell showing stolons, vesicles and a possible zooecium (top right corner), bed 5, Wrecclesham, Surrey. (GSM 98600.) 2, Stolons *in situ* in *Exogyra* shell, East Cliff, Folkestone, Kent. (GSM Zm 24.) Both author's coll., ×3.

Fig. 3. *Hallimondia fasciculata* gen. et sp. nov., holotype, Sandgate Beds, Copyhold Pit, Redhill, Surrey. (GSM Zk 3960–1; A. G. Davies coll.)

Fig. 4. *Limopsis dolomitica* sp. nov., holotype, base of Sandgate Beds, shore at Mill Point, Folkestone, Kent. (GSM Zm 2137; author's coll.) ×2.

Figs. 5*a*, *b*. *Anthonya woodsi* sp. nov., side (*a*) and dorsal (*b*) views of holotype, Atherfield Clay Series (Crackers), Atherfield, Isle of Wight. (GSM 98592; author's coll.)

this age determination has rested on an ammonite described by Jacob (1905, p. 411, pl. 13, fig. 3) as *Parahoplites milletianus* var. *peroni*. Thanks to the good offices of Dr. P. Destombes, I have been permitted to examine a suite of ammonites from the type horizon of Jacob's form (Minerai de Bois-des-Loges). They are all *Hypacanthoplites* of the *tardefurcata* Zone and include a specimen of *H.* cf. *milletioides* sp. nov. (Pl. 83, figs. 1*a*–*b*). It would appear, therefore, that in its type locality *T. arduennensis* is known definitely to occur only in the *tardefurcata* Zone but possibly may range into the *mammillatum* Zone. Judging from specimens of *T. arduennensis* in the Paris museums, this is the same species which Lamplugh and Walker (1903) described as *Terebrirostra lyra* var. *incurvirostrum* and which is found at the base of the *milletioides* Subzone at Newington, near Folkestone, and in the *regularis* Subzone (Shenley Limestone) at Leighton Buzzard.

Phylum MOLLUSCA

Class LAMELLIBRANCHIA

Family PARALLELODONTIDAE

Genus APTOLINTER nov.

Type species. Arca aptiensis Pictet and Campiche 1866, Lower Aptian, Europe.

Diagnosis. Like *Nanonavis* Stewart but longer, less angular, with relatively subdued umbonal region and more delicate radial sculpture on mid-shell. Hinge slender, anterior teeth short (text-fig. 11*a*).

Following Woods (1899, p. 35), the group of Lower Cretaceous species centred on *Arca aptiensis* has been referred to *Barbatia*. Moulds of the hinge of *A. aptiensis* are preserved in examples from the Perna Bed of Earlswood Common, Surrey (GSM Zb 3393–401), showing that the species is not an arcid but a parallelodontid close to *Nanonavis*. Other species of *Aptolinter* are: *Arca raulini*, *A. neocomiensis* d'Orbigny, and *A. cymodoce* Coquand. *Gilbertwhitea* Crickmay, 1930, is an allied genus with the shape of *Eonavicula carteroni* (d'Orbigny).

Family CUCULLAEIDAE

Genus CUCULLAEA Lamarck

Cucullaea tealli nom. nov. (= *Pectunculus obliquus* Keeping 1883, p. 116, pl. 6, fig. 1, *non* Defrance 1826, *nec* Andrzejovski 1832, *nec* Lea 1833, *nec* Munster 1835, *nec* Reeve 1843, *nec* Brown 1845).

Genus NORAMYA nov.

Type species. Arca forbesi Pictet and Campiche 1866, Lower Aptian, south-east England.

Diagnosis. Subtrapezoidal or subtrigonal, thick-shelled cucullaeids with sharp posterior carina and strongly incurved umbones. Ligamental area very large; hinge long and narrow, with few horizontal teeth but numerous perpendicular teeth, best developed anteriorly. Myophoric septum prominent. Surface with both concentric and radial sculpture, the radial element strongest on the anterior half and in the young.

Noramya differs from *Cucullaea* and *Idonearca* in hinge and surface sculpture and includes *Arca gabrielis* Leymerie, *A. dilatata* Coquand, *A. gresslyi* de Loriol, and *Cucullaea tumida* Matheron, all of Aptian or Neocomian age. The South African

Megacucullaea kraussi (Tate), also from the Lower Cretaceous, has a much bolder radial costation.

Genus CRYPTOCHASMA nov.

Type species. C. ovale sp. nov. (= *Cucullaea* sp. ?, Keeping 1883, p. 115, pl. 5, fig. 8, holotype; = *Cucullaea* cf. *cornueliana* Kirkaldy 1937, p. 118), Upper Aptian, England.

Diagnosis. Small, elongate cucullaeids with faint radial ornament; interior with myophoric septum and a ridge on the umbo; hinge area narrow, teeth parallel with the hinge-margin.

The internal ridge on the umbo and the elongate shape, approaching the Parallelodontidae, are the chief features of this genus, the type species of which is a characteristic fossil of the *cunningtoni* Subzone. The umbonal ridge is reproduced as a cleft on internal moulds (Plate 82, figs. 6*a*, 6*b*). In the Rhaetic-Jurassic genus *Catella* Healey the internal ridge is much stronger and corresponds to a constriction of the surface; the hinge-plate is broader, with the anterior teeth set obliquely across it.

Family LIMOPSIDAE

Genus LIMOPSIS Sasso 1827

Limopsis dolomitica sp. nov.

Plate 79, fig. 4

Holotype. GSM Zm 2137, base of Sandgate Beds, Mill Point, Folkestone, Kent (Author's Coll.).

Diagnosis. Limopsis averaging 13 mm. in length, narrower and more oblique than *L. albensis* Woods, with shorter, less rectilinear hinge line, and apparently no radial lines.

Limopsis is rare in the Lower Cretaceous and it is surprising to find it a common fossil in the base of the Sandgate Beds at Folkestone. The specimens are preserved in gritty dolomite, partly decorticated, and do not show the hinge. Also known from the Ferruginous Sands at Shanklin.

EXPLANATION OF PLATE 80

Figures natural size unless otherwise stated.

Figs. 1, 2. *Scittila nasuta* gen. et sp. nov., Atherfield Clay Series (Crackers), Atherfield, Isle of Wight. 1, Hinge of holotype (left valve) (overhanging valve-margin below figure number should not be mistaken for posterior lateral tooth). (SM B 12778.) 2, Hinge of right valve. (GSM 98608; author's coll.) Both ×3.

Fig. 3. *Icanotia pennula* sp. nov., holotype, Upper Perna Bed, Redcliff, Isle of Wight. (BM L16284.) ×1·5.

Fig. 4. *Epicyprina harrisoni* sp. nov., holotype, Folkestone Beds, Ivy Hatch, near Ightham, Kent. (GSM 98599; author's coll.) ×0·8.

Figs. 5*a*, *b*. *Proveniella rosacea* sp. nov., right side (*a*) and dorsal (*b*) view of holotype, Atherfield Clay, Nutbourne Brickworks, Shottermill, near Haslemere, Surrey. (GSM 98590; J. F. Kirkaldy coll.)

Figs. 6, 7. *Pachythaerus tealli* sp. nov. 6*a*, *b*, Side and interior of holotype, Lower Greensand, Potton, Bedfordshire. (GSM 98593; author's coll.) 7, Right valve, Iron Sands, Seend, Wilts. (BM 88836; W. Cunnington coll.) Both ×1·7.

Figs. 8*a*, *b*. *Pterotrigonia mantelli* sp. nov. 'Vinagel' squeeze from holotype-mould showing left side (*a*) and escutcheon (*b*), Sandgate Beds (Iron Sands), Parham Park, Sussex. (BM 9140; Mantell coll.)

Fig. 9. *Tortarctica similis* (J. de C. Sowerby), hinge of right valve, Albian, St. Florentin, Yonne, France. (BM. 41696.)

Fig. 10. *Deshayesites callidiscus* sp. nov., topotype, Atherfield Clay Series (Crackers), Atherfield, Isle of Wight. (SM B 27054; Wiltshire coll.)

Family TRIGONIIDAE

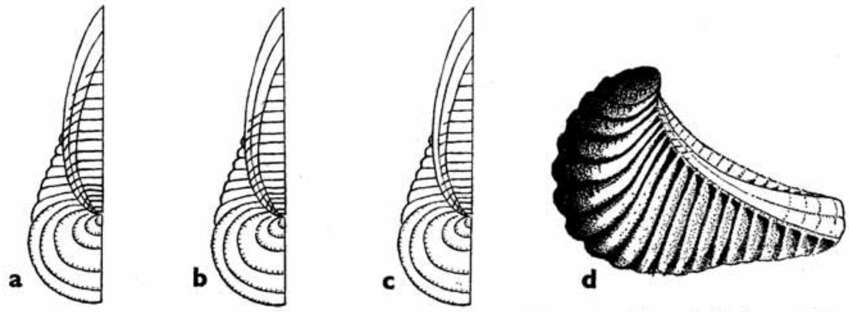
Genus PTEROTRIGONIA van Hoepen 1929

Pterotrigonia mantelli sp. nov.

Plate 80, figs. 8*a*, 8*b*; text-fig. 8 *b–d*

Holotype. BM 9140, Sandgate Beds, Parham Park, Sussex (Mantell Coll.).

Diagnosis. Like *P. vectiana* (Lycett) but larger, the ribs less strongly crenulated and the narrow areas bounding the escutcheon denuded of ribs except near the umbo.



TEXT-FIG. 8. Ornament of the escutcheon in *Pterotrigonia*. *a*, *P. vectiana* (Lycett), *fissicostatus* Zone. *b*, *P. mantelli anterior* sp. nov., subsp. nov., *bowerbanki* Zone. *c*, *d*, *P. mantelli* s.s., *nutfieldensis* Zone, ×1.

Lower Cretaceous *Pterotrigonia* of the *vectiana–aliformis* group form an evolutionary series, the principal line of progression being reduction of ribbing on and around the escutcheon, starting at the posterior end of the shell. *P. vectiana* (lectotype here selected: GSM 27075, figured Lycett 1875, pl. 24, figs. 10, 10*a*, *b*) is a Perna Bed species and has strong transverse ribbing that spreads from the escutcheon over the whole of the area, leaving only the posterior third of the area bare in mature shells. In *P. mantelli* the inner portion of the area, bounded externally by a groove, is bare for the posterior half of its length, the outer portion for about the posterior three-quarters. This species ranges through the whole of the Upper Aptian and the Lower Albian. An earlier form, tending towards *P. vectiana*, occurs in the *deshayesi* and *bowerbanki* Zones of the Lower Aptian, and may be regarded as a chronological subspecies, *P. mantelli anterior* subsp. nov. (type: the original of Pictet and Renevier 1847, pl. 14, figs. 2*a–c*, from the Aptian of Perte du Rhône, France; figured as *Trigonia aliformis*).

Family MYOCONCHIDAE

Genus MYOCONCHA J. de C. Sowerby 1824

Myoconcha delta sp. nov.

Plate 81, figs. 3, 4*a–b*

Holotype. GSM 20084, Iron Sands of Seend, Wiltshire (Cunnington Coll.).

Diagnosis. Similar to *M. cretacea* d'Orbigny, but with posterior end symmetrically convex, umbonal cavity not overhanging the adductor scar, and with a marginal posterior lateral tooth in the left valve.

There are ten specimens of this species in the Cunnington Collection in the Geological Survey Museum, either internal moulds or decorticated shells. It is not possible to say, therefore, whether the surface ornament agreed with that of *M. cretacea*, the only other member of the genus recorded from the British Cretaceous.

Family LIMIDAE

Genus LIMATULA S. V. Wood 1839

Limatula sabulosa sp. nov.

Plate 83, fig. 5

1942 *Limatula dupiniana* (d'Orbigny); Wright and Wright, p. 86.

Holotype. GSM 98606, Folkestone Beds (*Farnhamia* horizon), Coxbridge pit, Farnham, Surrey (Author's Coll.).

Diagnosis. Small, subelliptical, with symmetrically rounded ventral margin; posterior margin only slightly more convex than the anterior margin. Ears equal. Median part of shell with about twenty very narrow radial ribs, separated by broad depressions, more closely spaced on the posterior slope.

Limatula dupiniana (d'Orbigny) has fewer ribs and they are placed asymmetrically on the shell. *L. tombeckiana* (d'Orbigny) and *L. fittoni* (d'Orbigny) have fewer ribs, narrow interspaces, and more prominent ears. The species occurs sporadically in the *tardefurcata* and *mammillatum* Zones.

Family REQUIENIIDAE

Genus TOUCASIA Munier-Chalmas 1873

Toucasia lonsdalii (J. de C. Sowerby). The majority of specimens of this rudist, including the type, were obtained from iron sands at Stock Orchard, south of Calne. Others have been found at Lockswell Heath, near Calne, at Seend (GSM 44662), Parham Park, Sussex (GSM 52029), and near Headleywood Farm, Hampshire (GSM 98598). This is the only Lower Greensand representative of a group of lamellibranchs more typical of the Tethyan region and the fact that all the occurrences noted above are in the *cunningtoni* Subzone of the *nutfieldensis* Zone suggests an isolated penetration to the British Province.

EXPLANATION OF PLATE 81

Figures natural size unless otherwise stated.

Figs. 1*a*, *b*. *Cheloniceras* (*Epicheloniceras*) *gracile* sp. nov., side and venter of holotype, Ferruginous Sands (nodules near base of Group IX), shore below Walpen High Cliff, Atherfield, Isle of Wight. (GSM Zm 1953; author's coll.)

Figs. 2*a*, *b*. *Deshayesites forbesi* sp. nov., side and venter of holotype, Atherfield Clay Series (Crackers), Atherfield, Isle of Wight. (GSM 30918.)

Figs. 3, 4. *Myoconcha delta* sp. nov., Iron Sands, Seend, Wilts. 3, Holotype, partly decorticated. (GSM 20074.) 4*a*, *b*, Side and dorsal views of internal mould. (GSM 20087.) Both W. Cunnington coll.

Fig. 5. *Protodonax minutissimus* (Whitfield), internal mould of right valve. (GSM 44617.) Locality, horizon, and collector as before, $\times 1{\cdot}5$.

Family MACTRIDAE

Genus GELTENA Stephenson (in Vokes) 1946

Geltena meyeri sp. nov. (= *Mactra sp.*, Woods 1907, p. 177, pl. 27, figs. 17, 18). *Holotype*: original of Woods's pl. 27, figs. 17*a*, *b*), Ferruginous Sands ('Urchin Bed'), Shanklin, Isle of Wight.

Family ASTARTIDAE

Genus FREIASTARTE Chavan 1952

Freiastarte praetypica sp. nov. (= *Astarte sp.*, Woods 1906, p. 111, pl. 15, figs. 3, 4). *Holotype*: original of Woods's pl. 15, fig. 3. A characteristic species of the *jacobi* Zone. The matrix of Woods's originals in the Sedgwick Museum shows that they were obtained from Price's bed 1 of the Sandgate Beds, not the Folkestone Beds as now understood.

Genus ERIPHYLA Gabb 1864

Eriphyla pseudostriata (d'Orbigny) (= *Astarte pseudostriata* d'Orbigny 1850, *nom. nov*, for *A. substriata* Leymerie 1842, *non* Bronn 1835). Recorded from the Lower Greensand by Forbes, Fitton, and Morris under the name *Astarte substriata* Leymerie, but apparently missed by Woods. I have found it only in the *bowerbanki* and *nutfieldensis* Zones. An example from Shanklin in the Sedgwick Museum (B 13742) is in 'Urchin Bed' matrix.

Family CRASSATELLIDAE

Genus PACHYTHAERUS Conrad 1869

Pachythaerus tealli sp. nov.

Plate 80, figs. 6, 7

Holotype. GSM 98593, Lower Greensand, Potton, Bedfordshire.

Diagnosis. Shell small (up to 15 mm.), subtrigonal, height and length about equal, moderately inflated, with posterior diagonal angulation, beaks a little anterior. Postero-dorsal margin very feebly convex, antero-dorsal margin long and almost straight, anterior extremity low, posterior extremity truncated vertically. Surface with concentric ridges, lamellose on the beak and behind the angulation. Hinge typical of the genus; margins crenulate internally.

Common at Seend; a single valve from the *regularis* Subzone (bed 6) of East Cliff, Folkestone. Not described by Woods.

Genus DISPARILIA Chavan 1953

Disparilia disparilis (d'Orbigny). This primitive crassatellid, typically Neocomian, occurs as a great rarity in the Perna Bed of Surrey.

Genus SEENDIA nov.

Type species. *Crassatella saxoneti* Pictet and Roux, 1847, Albian, France.

Diagnosis. Oblong, inequilateral, umbo anterior, thick-shelled, compressed, lunule narrow, circumscribed by an incised line. Surface with concentric ridges and faint radial lines. Adductor and pedal scars deeply impressed, the posterior adductor mounted on a projecting plate. Margins crenulate internally. Hinge-plate narrow, with two cardinal teeth in each valve, 3*b* much larger than the others. Ligament sunk between the valves, apparently as in *Disparilia*.

This genus has the aspect of a Jurassic *Prorokia* without lateral hinge teeth. The type species is characteristic of the Iron Sands of Seend, whence Woods (1906, p. 104, pl. 14, figs. 2*a*, *b*, 3) figured an incomplete mould and an example with shell under the name *Astarte elongata* d'Orbigny. The latter is a Valanginian species of *Seendia*, less flat-sided than *S. saxoneti*, and with a sunken lunule and prominent umbo (see Pictet and Campiche 1886, pl. 124, figs. 8, 9). A piece of shell is chipped from the lunular region in the original of Woods's pl. 14, fig. 2*a*, making the umbo appear unnaturally acute.

Family SCAMBULIDAE

Genus ANTHONYA Gabb 1864

Anthonya cantiana Woods (1906, p. 130, pl. 19, figs. 4, 5). The types of this species were attributed to the Folkestone Beds, though their matrix is that of Price's Bed 1 of the Sandgate Beds (cf. *Freiastarte praetypica* sp. nov.).

Anthonya woodsi sp. nov. (= *A. sp.*, Woods 1906, p. 131, pl. 19, fig. 6). *Holotype*: GSM 98592, a bivalved example collected by the author (Pl. 79, fig. 5). The species is now known by several examples, all from the Crackers of Atherfield.

Genus MEDIRAON Vokes 1946

Mediraon sulcatum sp. nov.

1906 *Astarte sinuata* d'Orbigny; Woods, p. 104, pl. 14, figs. 7–9.

Holotype. The original of Woods 1906, pl. 14, fig. 7, from the Crackers of Atherfield, Isle of Wight.

Diagnosis. More equilateral than *M. sinuatum* (d'Orbigny), with pointed umbo and a less excavated lunular region.

There seems to be a complete gradation from the concentrically ribbed, equilateral, sharply trigonal shells of the type of *Astarte subacuta* d'Orbigny to the oblong shells with divaricate ribbing typical of *Mediraon* (type species *M. divaricatum* Vokes). The hinge-structure of *Mediraon* is seen both in *M. sulcatum* and in the Barremian form attributed to *A. sinuata* by Gillet (1921, pl. 1, figs. 13, 14; cf. Vokes 1946, pl. 6, figs. 6, 11). *Scambula* Conrad is intermediate in shape between *Mediraon* and *Anthonya*.

Family CARDITIDAE

Genus FENESTRICARDITA nov.

Type species. *Venus ?fenestrata* Forbes 1845, Lower Aptian, south-east England.

Diagnosis. Small, oblong shells with umbo well forward and not rising much above the hinge-line. Lunule deeply sunk but with margin of left valve pouted above tooth 2*b*. Surface with strong reticulate sculpture; posterior area flattened, with two or more nodular carinae. Hinge-teeth as in *Xenocardita*; margins crenulate internally.

The genus includes *Cardita tricarinata* d'Orbigny of the Cenomanian.

Genus TRAPEZICARDITA nov.

Type species. Cypricardia squamosa Keeping 1883, Aptian, England.

Diagnosis. Small, rounded oblong, inflated shells with ventral and dorsal margins straight and nearly parallel. Umbones terminal; lunule cordate; surface angulated posteriorly and with narrow radial ribs and periodic concentric lamellae. Hinge as in *Praeconia*; margins crenulate internally.

The genus includes *Cypricardia arcadiformis* Keeping. Both of these species were referred by Woods to *Trapezium* with question, though Keeping had correctly compared *T. squamosa* with *Cardita.* The latter species shows a curious resemblance in hinge-structure and shape to the Middle Jurassic *Praeconia rhomboidalis* (Phillips).

Family TELLINIDAE

Genus LINEARIA Conrad 1860

Linearia cornea sp. nov. (= *Tellina* (*Linearia*) *sp.*, Woods 1907, p. 175, pl. 27, fig. 9). *Holotype.* BM 48626, the original of Woods's pl. 27, fig. 9, from the Crackers of Atherfield. A characteristic *forbesi* Zone species. I have excavated the hinge of a left valve of my own collecting (GSM 98597) and find a single grooved triangular cardinal tooth under the beak and mere vestiges of anterior and posterior lateral teeth.

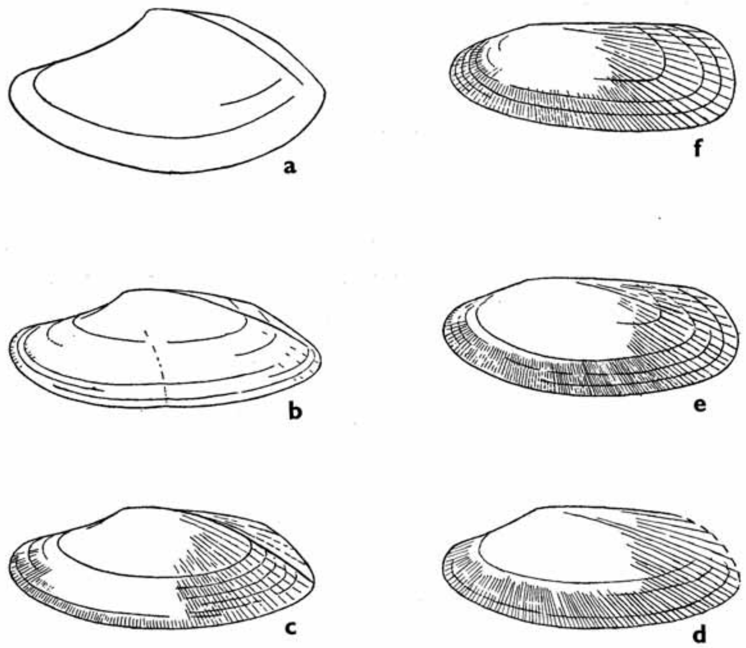
Family ICANOTIIDAE nov.

Diagnosis. Equivalve, closed, compressed, elongate and fragile tellinaceans. Outline subelliptical tending to oblong, anterior end narrowly rounded. Surface may be almost smooth, but usually with ribs or threads radiating from the beak, strongest on, or confined to, the posterior slope. Ligament external, opisthodetic, seated on nymphs. Hinge lucinoid, without lateral teeth, formula *3a*, *3b*/*2b*, *4b*, the teeth entire, *2b* and *3b* prominent, triangular, *3a* and *4b* subject to reduction or elimination. Large, deep, rounded pallial sinus. Habitat marine.

This nominal family is proposed for reception of the two genera *Icanotia* Stoliczka and *Scittila* gen. nov., discussed below. Species placed in these two genera have been generally referred to the Veneridae and the Tellinidae respectively, but are here regarded as closely allied derivatives of the Jurassic *Tancredia* adapted to life in a burrow. Although retaining the simple cardinal dentition and some of the external features of the Tancrediidae, their fragile shells, elongate form, deep pallial sinus, lack of lateral teeth and tendency to develop strong radial sculpture, combine to exclude them from that family. The Gariidae (= Psammobiidae), an essentially Tertiary and Recent group, differ from the Icanotiidae in having, typically, subequilateral shells, prominent nymphs, opisthogyral beaks and bifid principal cardinal teeth. Text-fig. 9 illustrates the line of evolution of the Icanotiidae. Radial sculpture, which eventually spread over the whole surface of *Icanotia*, had already appeared in *Tancredia*, being present behind the umbo in well-preserved examples of *T. donaciformis* Lycett from the Upper Lias (e.g. GSM FD 1536).

Genus ICANOTIA Stoliczka 1870

The nominal type species of *Icanotia* is *Psammobia impar* Zittel 1865, by original designation, but there has been some confusion as to the taxon to which this name applies (Casey 1953). *Psammobia impar* was proposed by Zittel as a substitute combination for *Capsa elegans* d'Orbigny 1844, which became a secondary homonym of *Solen elegans* Matheron 1842, when he transferred both species to the genus *Psammobia*. Under the Rules d'Orbigny's species, from the Cenomanian of Le Mans, is the taxonomic type of *Icanotia* and its correct name is *Icanotia impar* (Zittel). The form from the Gosau formation of Austria described and illustrated by Zittel as *Psammobia impar* is here



TEXT-FIG. 9. Evolution of shell-form in the Icanotiidae. *a*, *Tancredia donaciformis* Lycett, Lower and Middle Jurassic. *b*, *Scittila nasuta* group, gen. et sp. nov., Lower Cretaceous (Hauterivian–Lower Aptian). *c*, *S. nasuta* var. *radiata* var. nov., L. Cretaceous (L. Aptian, *fissicostatus–forbesi* Zones). *d*, *Icanotia pennula* sp. nov., L. Cretaceous (L. Aptian, *fissicostatus* Zone). *e*, *I. siliqua* sp. nov., L. Cretaceous (Upper Albian). *f*, *I. zitteli* sp. nov., Upper Cretaceous (Senonian).

designated *I. zitteli* sp. nov. (holotype: the original of Zittel 1865, pl. 2, fig. 4). Stoliczka (1870, p. 145) treated *Icanotia* as a subgenus of the venerid *Baroda* (= *Legumen* Conrad 1858), being influenced by similarities in external form and supposed identity of hinge-structures. It is evident from the text that Stoliczka had only imperfect specimens to go on and it now seems that his drawings of the hinge of *Icanotia* are inaccurate restorations. The hinges of *I. impar* (as seen in topotypes in the Muséum d'Histoire Naturelle, Paris), *I. pennula* sp. nov., and *I. siliqua* sp. nov. agree with that of *Scittila*, as does that of *I. pulchra*, figured photographically by Wade (1926, pl. 29, fig. 5). The genus has an almost world-wide distribution and ranges from Aptian to Maestrichtian but is never common. In the two Aptian species *I. studeri* (Pictet and Renevier) and *I. pennula* sp. nov. the beaks are more prominent and not so far forward as in later members of the genus, features which link them with *Scittila*.

Icanotia pennula sp. nov.

Plate 80, fig. 3; text-figs. 9*d*, 11*c*

Holotype. BM L 16284, Atherfield Clay Series, Upper Perna Bed, Sandown, Isle of Wight.

Diagnosis. Like *I. studeri* but anterior end more produced, posterior end truncated and ventral margin without pronounced upward sweep.

The holotype is a unique bivalved shell with the valves displaced so as to show the hinge.

Icanotia siliqua sp. nov.

Text-fig. 9*e*

1913 *Tapes* (*Icanotia*) sp., Woods, p. 431, pl. 62, figs. 14*a*, *b*.

Holotype. BM L 3379, Upper (Blackdown) Greensand, Blackdown, Devon, figured by Woods (1913, pl. 62, figs. 14*a–b*) as *Tapes* (*Icanotia*) sp.

Diagnosis. Oblong elliptical *Icanotia* with beak distance seven-tenths and maximum height and thickness at mid-length. Lunule narrow and deeply sunk. Postero-dorsal and antero-dorsal margins straight, converging on the inconspicuous umbo at an angle of 150°. Area of coarse radial sculpture covers a sector of about 25°; anteriorly the radii become closely spaced and weaker, are almost obsolete on the mid shell, but rejuvenate slightly at the anterior end.

I have located six specimens of this rare species in the British Museum and the Geological Survey Museum, all from the Upper Albian greensands of Blackdown, Haldon, and Seaton, Devon. An example from the Red Bed (*anglicus* Subzone) of Sandling Junction, near Hythe, Kent (GSM Zm 667), is too poor for certain determination.

The anterior end is more produced than is indicated in Woods's restored figure.

Genus SCITTILA nov.

Type species. *S. nasuta* sp. nov., Lower Aptian, south-east England.

Diagnosis. Very compressed Icanotiidae with no lunule and only an incipient escutcheon. Posterior margin obliquely truncated and posterior slope carinated. Umbo subcentral. A shallow furrow between umbo and middle of ventral margin. Radial sculpture may be obscure. Range: Hauterivian to Aptian.

Scittila nasuta sp. nov.

Plate 80, figs. 1, 2; text-figs. 9*b*, 9*c*

1907 *Tellina carteroni* d'Orbigny; Woods, p. 171, pl. 26, figs. 15, 16.

Holotype. The original of Woods's pl. 26, figs. 16*a–c*, from the Crackers of Atherfield, Isle of Wight.

The combination *Tellina carteroni* was proposed by d'Orbigny (1845, p. 420) as a substitute for *Tellina ? angulata* Deshayes (*in* Leymerie, 1842, pp. 3, 24), this being a homonym of *T. angulata* Linné. D'Orbigny illustrated *T. carteroni* by a specimen from the Neocomian of Marolles, France, which, judging from the figures, is a different species from that of Deshayes, which came from the Neocomian of Vendeuvre. Woods noted this discrepancy in the figures and assumed that it was due to imperfect preservation of the originals. Since the original of Deshayes's figure is lost and d'Orbigny's illustration is known to be restored, this view can be neither refuted nor confirmed. Whichever specimen is taken to represent d'Orbigny's species its identity with the English Lower Greensand forms can be assumed only on the premiss that it is incorrectly figured. Apart from the discrepancies in the figures, there are good reasons for regarding this assumption as unsafe. Stoliczka (1870, p. 123) stated that casts of *T. carteroni* show impressions of both cardinal and lateral teeth, and Gillet (1924, p. 136) in describing the hinge of this species alluded to its long lateral teeth A II and P II and to its bifid cardinal tooth 2*b*. The English species has no lateral teeth (Pl. 80, figs. 1, 2) and the cardinal teeth are undivided. Better agreement with d'Orbigny's figure is shown by a specimen of '*Tellina carteroni*' from the Hauterivian of Sainte Croix in the Sedgwick Museum, an internal mould without impressions of lateral teeth. In view of the uncertainty as to the characters of *T. carteroni* and since it is desirable that the type species of a genus should be free from such uncertainty, it is proposed to apply the combination *Scittila nasuta* to the Lower Greensand form previously described and figured by Woods as *T. carteroni*. Radial ornament may be seen faintly under magnification in the typical *S. nasuta* and is much more conspicuous in the var. *radiata* nov. (type: the original of Woods, 1907, pl. 26, fig. 17).

Family DONACIDAE?

Genus PROTODONAX Vokes 1945

Protodonax minutissimus (Whitfield). Small wedge-shaped shells, up to 13 mm. long, from the Iron Sands of Seend are referable to this species, originally described from the Aptian of the Lebanon and refigured by Vokes (1945, pl. 46, figs. 16–18; 1946, pl. 9, figs. 26–28). The Cunnington Collection in the Geological Survey Museum contains a cluster of moulds (GSM 44617) and an isolated left valve (GSM 44618). Apart from the Lebanon occurrence, *Protodonax* is well represented in the Cretaceous of the North American interior, though it does not seem to have been noted previously in western Europe.

Family SOLENIDAE

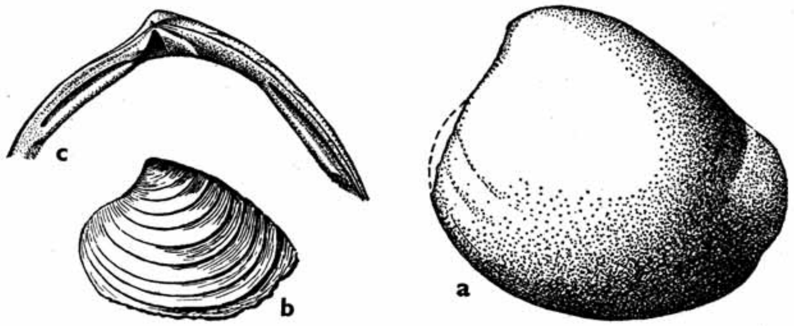
Genus SENIS Stephenson 1952

S. wharburtoni (Forbes). This common Lower Greensand species was referred to *Solecturus* by Forbes (1845, p. 237) and to *Pharus* by Woods (1909, p. 217) and is known only in closed shells or moulds. The valves of a specimen from the Crackers (GSM 3041) were prized apart, mounted in plaster, and cleaned out, thereby revealing an edentulous hinge, a narrow internal ridge extending obliquely forwards and downwards from the beak, and another, fainter ridge, closer to the shell margin, extending backwards from the beak. These are the characters of the genus *Senis* (type species *S. elongatus* Stephenson) recently described from the Cenomanian of Texas (Stephenson 1952, p. 120, pl. 31, figs. 8–13).

Family NEOMIODONTIDAE

Genus EOMIODON Cox 1935

Eomiodon cf. *libanoticus* (Fraas). A form conspecific with or allied to *E. libanoticus* of the Aptian of the Middle East was an unexpected find in the Lower Greensand of Dorset (Punfield Marine Band and westward equivalents). *Eomiodon* is a marine-brackish genus allied to the Purbeck–Wealden *Neomiodon* (Casey 1956), is characteristically Jurassic, and has not been noted previously in the British Cretaceous. Large internal moulds of *E.* cf. *libanoticus* from Worbarrow Bay (GSM Rh 2438, 2439, 2453, 2456)



TEXT-FIG. 10. *Eomiodon* cf. *libanoticus* (Fraas), Punfield Marine Band, Dorset. *a*, Internal mould, Worbarrow Bay (Bed 7) (GSM Rh 2438), ×1·3. *b*, Fragmentary juvenile, Corfe Castle Station (GSM Rh 2811), ×2. *c*. Hinge of right valve, Punfield (GSM 86398), ×7.

were recorded by Arkell (1947*b*, p. 171) as *Astarte obovata* J. de C. Sowerby, juveniles from Corfe Castle Station (GSM Rh 2811, 2823) as *Astarte subcostata* d'Orbigny. From a slab of 'Marine Band' collected at Punfield Cove I isolated a juvenile showing all the fine details of hinge-structure (GSM 86398; text-fig. 10*c*), just like *E. fimbriatus* (Lycett) of the Forest Marble, and Mr. S. W. Hester found another in the ironstone at Lulworth Cove (GSM 86653).

Family ARCTICIDAE

Genus TORTARCTICA nov.

Type species. Isocardia similis J. de C. Sowerby 1826, Lower Albian, south-east England.

Diagnosis. Large trigonal-ovate, well-inflated shells with prominent, spirally enrolled beaks. Lunular region depressed, escutcheon limited by blunt carinae. Hinge cyprinoid, formula A I, III, 1, 3*a*, 3*b*, P I/A II, 2*a*, 2*b*, 4*b*, P II. A I and A II vestigial; A III pustular; 1 spoon-shaped; 3*b* bifid, united with 3*a* into a single curved, strongly opisthocline tooth lying almost horizontal; 2*a* and 2*b* nodular, separated by a constriction; posterior laterals close behind the nymph.

Tortarctica is an arcticid related to *Venilicardia* and *Epicyprina* in which the hinge has been modified in correlation with spiral enrolment of the beaks, thus simulating the Recent *Glossus* (= *Isocardia*), in which there is a much more radical alteration of hinge-structure. I have discussed elsewhere (Casey 1952, pp. 146–50) the homologies of the hinge-teeth of other Mesozoic arcticids wrongly assigned to the Glossidae (= Isocardiidae). Sowerby (1826, p. 27) had attributed his *Isocardia similis* to the greensand of 'Sandgate, near Margate'; Woods (1907, p. 152) correctly identified the matrix as that of the *mammillatum* Zone. The species ranges through the whole of the Folkestone Beds. There is a particularly fine example of the right valve in the British Museum (BM 41696) from the Albian of St. Florentin, Yonne, France, labelled *Cyprina cordiformis* d'Orbigny. Though preserved in hard glauconitic sandstone, it furnished the hinge-preparation illustrated in Pl. 80, fig. 9. The hinge of the left valve is best seen in GSM Zm 846. D'Orbigny's *Cyprina cordiformis*, also found in the English *mammillatum* Zone, is also referable to *Tortarctica*.

Genus EPICYPRINA Casey 1952

Epicyprina harrisoni sp. nov.

Plate 80, fig. 4; text-fig. 11*d*

Holotype. GSM 98599, a silicified right valve, Folkestone Beds, Ivy Hatch, near Ightham, Kent (Author's Coll.).

Diagnosis. Large *Epicyprina* (averaging 115 mm. long), subtrigonal, very inequilateral; inflation moderately strong but uneven, the shell flattening in a postero-ventral direction. Posterior ridge very faint. Umbo well recurved, prosogyrous, placed at the anterior quarter of the length. Lunular region well excavated, the lunule depressed, obscurely circumscribed, the margin straight. Postero-dorsal margin long, convex, falling steeply to a short, subvertical posterior margin. Dorsal margin sweeping up in a continuous curve with the narrowly rounded anterior extremity. Hinge typical of the genus.

This is the *Cyprina angulata* of Harrison (Gossling 1929, p. 255). The sharp decline of the postero-dorsal margin, narrowly rounded anterior extremity, and the deep lunular area are the chief distinguishing features compared with *Epicyprina angulata* (J. Sowerby) of the Upper Greensand. *E. harrisoni* occurs sporadically through the *jacobi* and *tardefurcata* Zones, but nowhere in greater numbers than around Ightham.

Genus PROVENIELLA Casey 1952

Proveniella rosacea sp. nov.

Plate 80, figs. 5*a*, 5*b*

1938 *Cyprina sedgwicki* (Walker); Kirkaldy and Wooldridge, p. 139.

Holotype. GSM 98590, Atherfield Clay, Nutbourne Brickworks, Shottermill, near Haslemere, Surrey (J. F. Kirkaldy Coll.).

Diagnosis. Smaller, more rotund, and less elongate than *Proveniella meyeri* (Woods), the hinge slender, with posterior lateral tooth P III tucked under the shell-margin.

Characteristic of the Atherfield Clay of the Haslemere district. One of Dr. Kirkaldy's specimens (GSM 98588) was dissected to expose the hinge, on which generic determination depends. *Isocyprina sedgwicki* (Walker) has a steeply falling, convex postero-dorsal margin, a circumscribed lunule, and a different hinge.

Genus VENILICARDIA Stoliczka 1870

Venilicardia sowerbyi (Woods). Lectotype here selected: the original of Woods, 1907, pl. 21, fig. 8, from the Hythe Beds of Hythe, Kent (Sedgwick Museum). Shells collected by Fitton from the Hythe Beds around Folkestone and Hythe were identified by J. de C. Sowerby as *Cyprina angulata* (Fitton 1836, p. 128). D'Orbigny (1850, p. 78) renamed them *Cyprina sowerbyi*, but gave no description, figure, or indication. Nevertheless, Woods (1907, p. 138) used the combination *Cyprina sowerbyi* d'Orbigny for a common species of *Venilicardia* of the Lower Greensand. D'Orbigny's use of the name being nude, the combination *Cyprina sowerbyi* must be attributed to Woods, with Woods's examples as types. Neither d'Orbigny nor Woods seems to have consulted Fitton's originals. Some of them (GSM 52030, 18862) are here identified as *Venilicardia inornata* (d'Orbigny).

Family CORBICULIDAE

Genus FILOSINA Casey 1955

Filosina cf. *gregaria* Casey. Internal moulds indistinguishable from those of the common Weald Clay and Wealden Shales *Filosina* occur in the Lower Greensand ironstone of Lulworth Cove, associated with *Eomiodon* and *Exogyra*. GSM 86652 shows the diagnostic features of the hinge.

Family PINNIDAE

Genus PINNA Linné 1758

Subgenus STEGOCONCHA Böhm 1907

The large Stegoconchas of the Lower Greensand are a curious omission from earlier literature. There are at least three species, apparently undescribed, some attaining nearly a foot in length. The largest is comparable with *P.* (*S.*) *iburgensis* Weerth and occurs in the Perna Bed of the Isle of Wight (e.g. BM 32584; also Sandown Museum); another, similar to *P.* (*S.*) *hombresi* Pictet and Campiche, is found in the Crackers (e.g. BM 48626). The Hythe Beds of East Kent yield moulds of a *Stegoconcha* up to 10 inches long, here listed as *P.* (*S.*) cf. *gervaisii* Dumas (e.g. GSM Zm 2212; also British Museum and Folkestone Museum).

Family ISOGNOMONIDAE

Genus INOCERAMUS W. Smith 1816

Inoceramus coptensis sp. nov.

Plate 82, fig. 5

1900 *Inoceramus* sp., large; Jukes-Browne, p. 228.
1939 *Inoceramus ? neocomiensis* d'Orb.; Jackson, p. 76.
1941 *Inoceramus* cf. *anglicus* Woods; Brown, p. 11.
1949*b* *Inoceramus* sp. nov.; Casey, p. 225.
1955*c* *Inoceramus* sp. nov.; Casey, p. 232.

Holotype. GSM Zm 26, a left valve, Folkestone Beds, *regularis* Subzone, bottom stone band, near Copt Point, Folkestone, Kent (Author's Coll.).

Diagnosis. Shell inequivalve, very inequilateral, of moderate inflation, longer than high, greatest length from umbo to postero-ventral extremity. Left valve tumid, with greatest convexity about one-third the distance from umbo to ventral margin; posterior and postero-dorsal regions compressed; anterior area fairly small, steeply turned, excavated near the umbo; ventral margin convex, forming a parabolic curve together with the posterior margin; hinge-line about three-quarters the length of the shell, making rather more than a right angle with the anterior margin, which is nearly straight; umbo anterior, pointed, incurved, salient above the hinge-line. Right valve considerably less tumid than the left, with a much smaller and less incurved umbo. Surface with narrow concentric ribs and growth-rings of asymmetrical curvature; on the internal mould the ribs are sharper and separated by wide, shallow concave interspaces.

Characteristic of the *regularis* Subzone and the base of the *mammillatum* Zone in southern England, this species is apparently ancestral to *I. salomoni* of the *mammillatum* Zone, with which it overlaps in range. It is relatively longer than *I. salomoni*, less inequivalve, has a less inflated, non-sulcate left valve, longer hinge-line, and smaller anterior area. The Aptian *I. neocomiensis* d'Orbigny is shorter, has more evenly curved ribs, and is less tumid below the umbo.

Inoceramus salomoni d'Orbigny

One of the commonest fossils in the *mammillatum* Zone of Europe and may be collected in thousands at Copt Point, Folkestone. Yet every example recorded, figured, or described under this name is a left valve. Search for the missing right valve at Copt Point drew attention to some flat, operculum-like shells previously identified as '*Lima*' *montana* Pictet and Roux; these eventually proved to belong to the present species by discovery of two examples with the valves joined (GSM Zk 4564, 4565) (text-fig. 11*b*). I am of the opinion that the original *Lima montana* of Pictet and Roux (1853, pl. 43, figs. 1*a*, *b*), from the Albian of Saxonet, is also based on a right valve of *I. salomoni*. Since other lamellibranchs in the *mammillatum* Zone are commonly found in a bivalved condition, the rarity of double-valved *I. salomoni* is presumably due to exceptionally weak attachment of the valves. With the two halves of the shell so different in shape, current-sorting seems an obvious explanation of the rarity of isolated right valves.

EXPLANATION OF PLATE 82

Figures natural size unless otherwise stated.

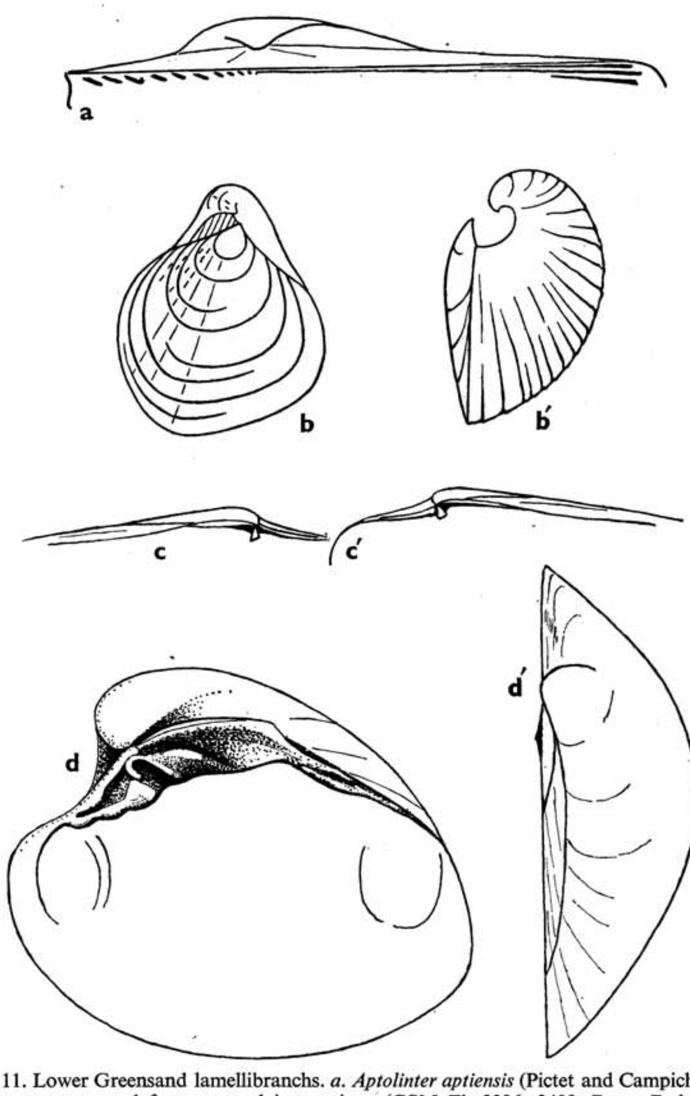
Figs. 1*a*, *b*. ***Parahoplites cunningtoni*** sp. nov., holotype, Iron Sands, Seend, Wilts. (OUM K 184; E. C. Davey coll.)

Figs. 2, 3. ***Prodeshayesites obsoletus*** gen. et sp. nov. 2*a*, *b*, Nucleus of holotype, Perna Bed, Woodhatch, Surrey. (BM C 36944.) 3, Phragmocone, Upper Perna Bed, Atherfield, Isle of Wight. (Museum of Isle of Wight Geology, Sandown, no. 88.) ×0·5.

Figs. 4*a*, *b*. ***Cuneocorbula arkelli*** sp. nov., holotype, bed 7, Worbarrow Bay, Dorset. (GSM Rh 2466.) *a* ×2, *b* ×3.

Fig. 5. ***Inoceramus coptensis*** sp. nov., holotype, Folkestone Beds (*regularis* Subzone), East Cliff, Folkestone, Kent. (GSM Zm 26; author's coll.)

Figs. 6*a*, *b*. ***Cryptochasma ovale*** gen. et sp. nov., left side (*a*) and dorsal (*b*) views of internal mould, Iron Sands, Seend, Wilts. (GSM 18676; W. Cunnington coll.) ×1·5. (The straight posterior margin is due to breakage.)



TEXT-FIG. 11. Lower Greensand lamellibranchs. *a. Aptolinter aptiensis* (Pictet and Campiche), hinge of right valve reconstructed from natural impressions (GSM Zb 3396, 3400, Perna Bed, Earlswood Common, Surrey), ×4. *b, b′*, *Inoceramus salomoni* d'Orbigny, diagrammatic sketch of right side (*b*) and posterior end (*b′*), based mainly on GSM Zk 4565, main *mammillatum* bed, Copt Point, Folkestone, ×1. *c, c′*, *Icanotia pennula* sp. nov., hinges of left (*c*) and right (*c′*) valves of holotype, ×2. *d, d′*, *Epicyprina harrisoni* sp. nov., interior and hinge (*d*) and dorsal view (*d′*) of holotype (right valve), ×0·66.

Family OSTREIDAE

Genus EXOGYRA Say 1820

Exogyra latissima (Lamarck) (= *Gryphaea latissima* Lamarck 1801, = *Gryphaea couloni* Defranc 1821, = *Gryphaea sinuata* J. Sowerby 1822, = *Gryphaea aquila* Brongniart 1822). This synonymy has been pointed out by several authors, for example Pervinquière (1912, p. 176) and Renngarten (1926, p. 60). English authors, in defiance of the Rules of Priority, have preferred the combination *Exogyra sinuata* (J. Sowerby).

Family CORBULIDAE

Genus CUNEOCORBULA Cossmann 1886

Cuneocorbula arkelli sp. nov.

Plate 82, figs. 4*a*, 4*b*

1947*b* *Anthonya cornueliana* (d'Orbigny); Arkell, p. 171.

Holotype. GSM Rh 2466, Lower Greensand (bed 7 of Arkell 1947*b*, p. 176), Worbarrow Bay, Dorset.

Diagnosis. Shell small (up to 16 mm. long), elongate, ovate-trapezoidal, compressed, not strongly inflated, produced posteriorly, umbo small, placed far forward. Anterior extremity broadly rounded, forming a continuous curve with the convex ventral margin; posterior-dorsal margin straight or feebly concave; posterior margin straight, inclined strongly forwards, angular where it meets the dorsal and ventral margins. A sharp carina extends backwards from umbo to postero-ventral angle, and another from umbo to postero-dorsal angle, the area between them slightly concave. Surface with fine concentric ridges which do not cross the umbonal carina to the posterior area. Hinge imperfectly known; right valve with a triangular cardinal tooth below the beak, margins of the valve grooved.

This is the small lamellibranch ('*Anthonya*') which Arkell (1947*b*, p. 176) described as a special feature of the Worbarrow ironstone (bed 7), correlated with the Punfield Marine Band. Specimens are internal and external moulds with impressions of part of the hinge. A possibly allied form occurs in the top of the Wealden Shales in the Isle of Wight (e.g. GSM 98601). Resemblance to the scambulid *Anthonya* is very superficial.

Family PHOLADIDAE

Genus XYLOPHAGELLA Meek 1876

Xylophagella zonata sp. nov. (= *Turnus sp.*, Woods 1909, p. 234, pl. 38, figs. 16, 17). *Holotype*: BM L 4996, the original of Woods's pl. 38, figs. 16*a*, *b*. A wood-borer, typically Gault, but found also in the *mammillatum* Zone.

Class GASTROPODA

Family PSEUDOMELANIDAE

Genus BRIGHTONIA nov.

(*Mr. A. G. Brighton, Curator of the Geological Collections, Sedgwick Museum, Cambridge*)

Type species. *Brightonia turris* gen. et sp. nov., Upper Aptian, southern England.

Diagnosis. Tall, conical, many-whorled Pseudomelanidae; whorls concave, shouldered at the sutures; base flat, angular or sharply turned at the periphery; aperture trapezoidal; columella lip slightly arcuate, reflected. Surface with fine spiral striations and crescent-shaped growth-lines.

Brightonia turris gen. et sp. nov.

1883 *Nerinea* sp.; Keeping, p. 94, pl. 3, figs, 7, 7*a*.

Holotype. The original of Keeping's pl. 3, fig. 7, from the Lower Greensand of Upware, Cambridgeshire.

Diagnosis. *Brightonia* 90–100 mm. long, with apical angle of about 18°. Whorls fifteen or more, concave, well shouldered; base angular, keeled; spiral striations four to 1 mm. on final whorl.

In addition to Keeping's originals a suite of partly crushed specimens from Faringdon Folly (GSM Zk 4991–4) is now available. A true *Pseudomelania* occurs in the Atherfield Clay Series and is probably that referred to by Keeping when describing this species.

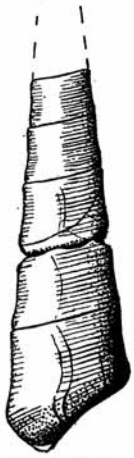
Brightonia sandlingensis gen. et sp. nov.

Text-fig. 12

Holotype. GSM 98605, *mammillatum* Zone, Sandling Junction sandpit, near Hythe, Kent (Author's Coll.).

Diagnosis. Slender *Brightonia* 60–70 mm. long, with apical angle about 12°. Whorls twelve or more, slightly concave, feebly shouldered, the lower shoulder the stronger; base flat, narrowly rounded at the periphery. Spiral striations five to 1 mm. on last whorl, producing a microscopic reticulation with the growth-lines.

The holotype is the only example with shell, though there are a number of internal moulds which apparently belong to this species.



TEXT-FIG. 12. *Brightonia sandlingensis* gen. et sp. nov., holotype, *mammillatum* bed, Sandling Junction sandpit, near Hythe, Kent. GSM 98605, ×1·5.

Class CEPHALOPODA

Order AMMONOIDEA

Family DESMOCERATIDAE

Genus BEUDANTICERAS Hitzel 1905

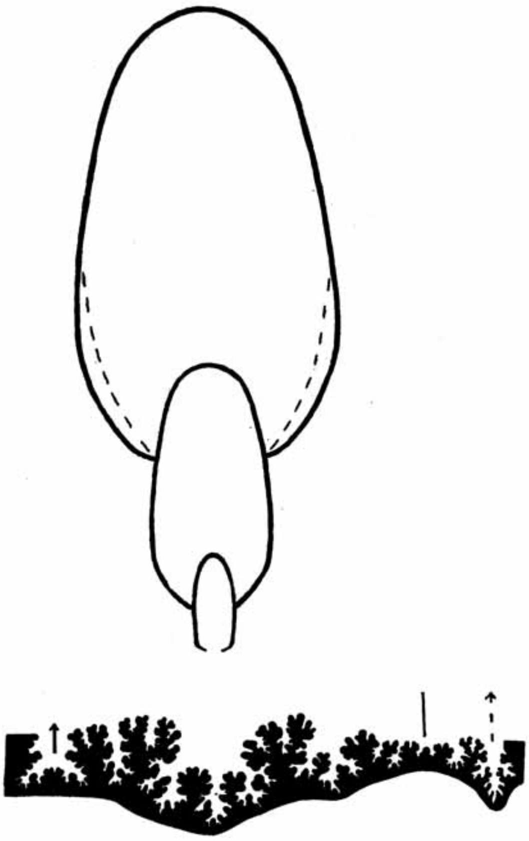
Beudanticeras newtoni nom. nov. for *Ammonites* (*Desmoceras*) *beudanti* var. *ligatus* Newton and Jukes-Browne (*in* Jukes-Browne 1900, p. 443) (*non Ammonites ligatus* d'Orbigny 1841). It is not possible to locate any of Newton and Jukes-Browne's originals of this very common *mammillatum* Zone ammonite and Spath's (1923*c*, p. 58) designation of a 'lectotype' of his own collecting is invalid. This specimen (BM C 28827, figured Spath, ibid., pl. 3, figs. 3*a*, *b*) is here designated *neotype* of *A*.(*D*) *beudanti* var. *ligatus* Newton and Jukes-Browne and so becomes automatically the type of *B. newtoni* nom. nov.

Family DESHAYESITIDAE

Genus PRODESHAYESITES nov.

Type species. Ammonites fissicostatus Phillips 1829, p. 129, pl. 2, fig. 49, Speeton Clay, Yorkshire.

Diagnosis. Like *Deshayesites* but with flatter, loosely coiled whorls, and ventral ribs in the form of chevrons; suture-line with relatively low elements.



TEXT-FIG. 13. *Prodeshayesites obsoletus* gen. et sp. nov., whorl-section and suture-line of holotype, Perna Bed, Woodhatch, near Reigate, Surrey. BM C 36944, ×1.

Prodeshayesites obsoletus gen. et sp. nov.

Plate 82, figs. 2, 3; text-fig. 13

1845 *Ammonites* ? resembling *A. leopoldinus* d'Orbigny; Forbes, p. 355.
1847 *Ammonites leopoldinus* d'Orb.; Fitton, p. 296, table facing p. 289.

1887 *Ammonites leopoldinus*; Norman, pp. 29–30.
1889 *Ammonites leopoldinus* d'Orb.; Bristow, p. 266.
1922 *Parahoplites* spp. n. cf. *laeviusculus* (v. Koenen); Butler, p. 316 (*pars*).
1923*c* *Parahoplitoides laeviusculus* (v. Koenen); Spath, p. 66 (*pars*).
1930*a* *Deshayesites* aff. *laeviusculus* (v. Koenen); Spath, p. 434 (*pars*).
1933 *Deshayesites* aff. *laeviusculus* (v. Koenen); Chatwin (in Dines and Edmunds), p. 117.

Holotype. BM C 36944, Atherfield Clay Series, Perna Bed, Woodhatch, near Reigate, Surrey.

Diagnosis. More compressed than *P. laeviusculus*, the phragmocone more involute and with mere traces of ribbing.

Characteristic of the Perna Bed and easily recognized by the smooth, desmoceratid-like phragmocone.

Genus DESHAYESITES Kasansky 1914

Deshayesites forbesi sp. nov.

Plate 81, figs. 2*a*, 2*b*

1845 *Ammonites Deshayesi* Leymerie; Forbes, p. 354, pl. 21, fig. 2.
1930*a* *Deshayesites deshayesi* (Leymerie MS.) d'Orbigny sp.; Spath, p. 424 (*pars*).

Holotype. GSM 30918, Atherfield Clay Series, Crackers, Atherfield, Isle of Wight.

Diagnosis. Phragmocone resembling that of *D. deshayesi* but with an oblique umbilical wall and with a more feebly ribbed nucleus that lacks the smooth flat ventral band of that species. Ribs close up on last three-quarters of whorl so that rib-count for final whorl is 50–60 compared with 45 in *D. deshayesi*.

This common species has been generally mistaken for *D. deshayesi* and has a long synonymy. It ranges through the whole of the Atherfield Clay Series above the Perna Bed, reaching its maximum in the *callidiscus* Subzone, and is eminently suited as a zone fossil. The true *deshayesi*, as represented by d'Orbigny's types from the Argiles à Plicatules of Bailly-aux-Forges (Haute-Marne) (lectotype here selected: the original of Wright 1957, p. L387, fig. 505), occurs in the lower part of Group IV of Atherfield and in the base of the Hythe Beds.

Deshayesites fittoni sp. nov.

Plate 84, figs. 4*a*, 4*b*

Holotype. GSM Zm 1843, Atherfield Clay, 25–30 feet above Perna Bed, Atherfield, Isle of Wight (Author's Coll.).

Diagnosis. Similar to *D. latilobatus* (Sinzow) (= *Hoplites deshayesi* Neumayr and Uhlig, pl. 45, figs. 1, 1*a*, *b*) but smaller and with more strongly flexed ribbing.

Not uncommon in the middle part of the Atherfield Clay of the Isle of Wight, though generally crushed or in body-chamber fragments only. Costation is irregular and variable, some densely ribbed forms approaching *D. weissi* (e.g. GSM Zm 1688). The *fittoni* Subzone is the most likely correlative of von Koenen's *weissi* Zone of the German succession.

Deshayesites callidiscus sp. nov.

Plate 80, fig. 10

1930*a* *Deshayesites* aff. *latilobatus* (Sinzow); Spath, p. 425.
1930*a* *Deshayesites kiliani* Spath, p. 429 (*pars*).

Holotype. BM 48836, Atherfield Clay Series, Crackers, Atherfield, Isle of Wight.

Diagnosis. Like *D. kiliani* Spath, but with a more rectangular whorl-section and more numerous ribs that do not form periodic bulges around the umbilicus.

Found in both the Crackers and the Upper Lobster Beds. Not common, though well represented in the museums.

Genus DUFRENOYIA (Burckhardt MS.) Kilian and Reboul 1915

Dufrenoyia transitoria sp. nov.

Plate 83, figs. 3*a*, 3*b*

1930*a* *Deshayesites* aff. *grandis* Spath, p. 427, pl. 17, fig. 1.
1935 *Deshayesites* aff. *laeviusculus* (v. Koenen); Swinnerton, p. 31.

Holotype. BM C 29617, base of Carstone, Hunstanton, Norfolk.

Diagnosis. Similar to *Deshayesites grandis* Spath, but with the clavate ventral margins of *Dufrenoyia* in the young and a greater tendency to smoothness in mid-life.

Characteristic of the lower half of the *bowerbanki* Zone and one of the commonest ammonites in the ledges of Lower Crioceras Bed at the mouth of Whale Chine, Atherfield. Found also as a remanié fossil in the Sutterby Marl.

Family DOUVILLEICERATIDAE

Genus CHELONICERAS Hyatt 1903

Subgenus CHELONICERAS *s.s.*

Cheloniceras (*Cheloniceras*) *parinodum* sp. nov.

Plate 84, fig. 1; text-fig. 14*a*

Holotype. An example collected by Professor T. Matsumoto from the top of Group IV, Atherfield.

Diagnosis. Whorls suboctagonal, depressed-coronatiform, widest at the umbilical tubercle. Umbilicus about 35 per cent. of the diameter, with high, steep wall, rounded at the rim. Primary ribs pass straight up the flank, every third or fourth producing a bifurcating secondary; tertiary ribs interposed irregularly in ones, twos, and threes (mostly in twos) between the primaries and mostly ending at mid-flank, some reaching the umbilical margin. All ribs in equal relief on the venter. Primary ribs bear umbilical and lateral tubercles, represented by radially elongated nodes on the internal mould, the two rows of nodes being of equal strength. Twenty-five ribs (9 primaries) to the half-whorl at 60 mm. diameter. With further growth the ribs become increasingly thick, close, and blunt, tubercles swell into prominent bullae, and umbilicus widens. Thirty-eight ribs (15 primaries) at 120 mm. diameter. Lateral tubercle lost at about 180 mm. diameter; costation eventually simplified to alternately long and short ribs.

This is the earliest species of *Cheloniceras* known in the Lower Greensand, its appearance marking the base of the *deshayesi* Zone. In its evolute coiling, thick, simple ribbing and equalization of the umbilical and lateral tubercles it shows affinities with *Procheloniceras*, an earlier development of the Douvilleiceratidae.

Subgenus EPICHELONICERAS Casey 1952

Cheloniceras (*Epicheloniceras*) *martinioides* sp. nov.

Plate 84, figs. 2*a*, 2*b*; text-figs. 14*d*, 14*e*

1847 *Ammonites Martini*; Fitton, p. 307 (*pars*).
1930*a* *Cheloniceras martini* (d'Orbigny); Spath, p. 452 (*pars*).

Holotype. GSM 98603, Hythe Beds (Boughton Group), Skinner's Quarry, Boughton Mount, near Maidstone, Kent (Author's Coll.).

Diagnosis. Similar to *Ch.* (*E.*) *tschernyschewi* (Sinzow) to 40 mm. diameter, after which the costation becomes relatively coarser, with fewer tertiary ribs, and strong lateral and ventral tubercles are retained longer.

A typical fossil of the Boughton Group and especially common in the Upper Crioceras Beds of the Isle of Wight, which have provided many of the specimens of '*Ammonites martini*' in the museums and cited in the literature. D'Orbigny's original *A. martini*, from the Gargasian of south-east France, is now represented in the d'Orbigny Collection in Paris by a few indeterminable nuclei and I have found no specimens or subsequent illustrations that agree with the protographs. Furthermore, to my knowledge none of the French Gargasian species to which the name *martini* could conceivably be linked agrees with those of the German and British Provinces, wherein a '*martini* Zone' has been employed since the time of von Strombeck (1861).

Cheloniceras (*Epicheloniceras*) *debile* sp. nov.

Plate 84, figs. 3*a*, 3*b*; text-fig. 14*b*

Holotype, GSM Zm 1952, Ferruginous Sands, Upper Crioceras Beds, below Walpen Chine, Chale Bay, Isle of Wight (Author's Coll.).

Diagnosis. An early *tschernyschewi* stage, with coronate-polygonal whorl-section, ventral sulcus, prominent ventral and lateral tubercles, and groups of three to four intermediary ribs, established at 20 mm. diameter. Thereafter ventral tubercles degenerate into ill-defined nodes, the venter becomes flat, and finally, at about 70 mm. diameter, broadly rounded. Ribbing rather blunt. After 20–25 mm. diameter each group of intermediary ribs differentiates into an anterior secondary, feebly bullate on the venter and connected firmly to the lateral tubercle, and two or three tertiaries which mostly reach to the umbilicus. Lateral tubercle lost between 70 and 90 mm. diameter; close, rounded ribs then supervene, radial or slightly reclined on the flank, broadening a little as they pass over the venter, and either bifurcating from the umbilical tubercle or ending freely at the umbilical margin. Thirty-six ribs and ten lateral tubercles at 60 mm. diameter; about forty-two ribs at 120 mm. diameter.

This species characterizes the middle and upper parts of the Upper Crioceras Beds and is known in isolated examples from the base of the Upper Crioceras Beds and from the Boughton Group of Kent. Its outstanding feature is early degeneration of the ventral tubercles.

Cheloniceras (*Epicheloniceras*) *gracile* sp. nov.

Plate 81, figs. 1*a*, 1*b*; text-fig. 14*c*

Holotype. GSM Zm 1953, Ferruginous Sands, Group IX (bed 35*a*), Walpen High Cliff, Chale Bay, Isle of Wight (Author's Coll.).

Diagnosis. The *tschernyschewi* stage ends at 20–25 mm. diameter. Ventral and lateral tubercles then disappear, whorl-section becomes subquadrate-depressed, venter flat, and costation simplifies to low, closely spaced, rounded ribs, most prominent on the venter. Ribs slightly arcuate on the flanks, straight on the venter; primaries connected to a small umbilical tubercle; two or three intermediaries to every primary, but irregularly distributed, some ending at mid-flank, others join the umbilical tubercle. Forty-five ribs and fifteen tubercles at 45 mm. diameter. With further growth the venter becomes broadly rounded, the ribbing finer, denser, and more subdued, degenerating at about 130 mm. diameter into low flattened bands with superimposed coarse striae. Ribbing rejuvenates at very large diameters. Suture-line of normal *Cheloniceras* pattern, but composed of unusually long and deeply dissected elements; median saddle in the principal lobe exceptionally slender and almost severed at the middle.

This densely ribbed species of *Epicheloniceras* is unlikely to be mistaken. It occurs in the Boughton Group around Maidstone and is localized more precisely in the Isle of Wight, where it forms part of the rich ammonite fauna of the Group IX nodules (bed 35*a*).

Family PARAHOPLITIDAE

Subfamily PARAHOPLITINAE

Genus PARAHOPLITES Anthula 1899

Parahoplites cunningtoni sp. nov.

Plate 82, figs. 1*a*, 1*b*

1850 *Ammonites Nutfieldensis* Sow.; Cunnington, p. 454 (*pars*).
1930*a* *Parahoplites* aff. *campichei* (Pictet and Renevier); Spath, p. 439 (*pars*).

Holotype. OUM K 184, Iron Sands of Seend, Wiltshire (E. C. Davey Coll.).

EXPLANATION OF PLATE 83

Figures natural size unless otherwise stated.

Figs. 1, 2. *Hypacanthoplites milletioides* sp. nov. 1*a*, *b*, Phragmocone, Minerai de Bois-des-Loges, Grandpré (Ardennes), France. (Muséum National d'Histoire Naturelle, Paris.) 2, Holotype, crushed body-chamber, *milletioides* Subzone, Sandling Junction, near Hythe, Kent. (GSM 70559; author's coll.) ×0·5.

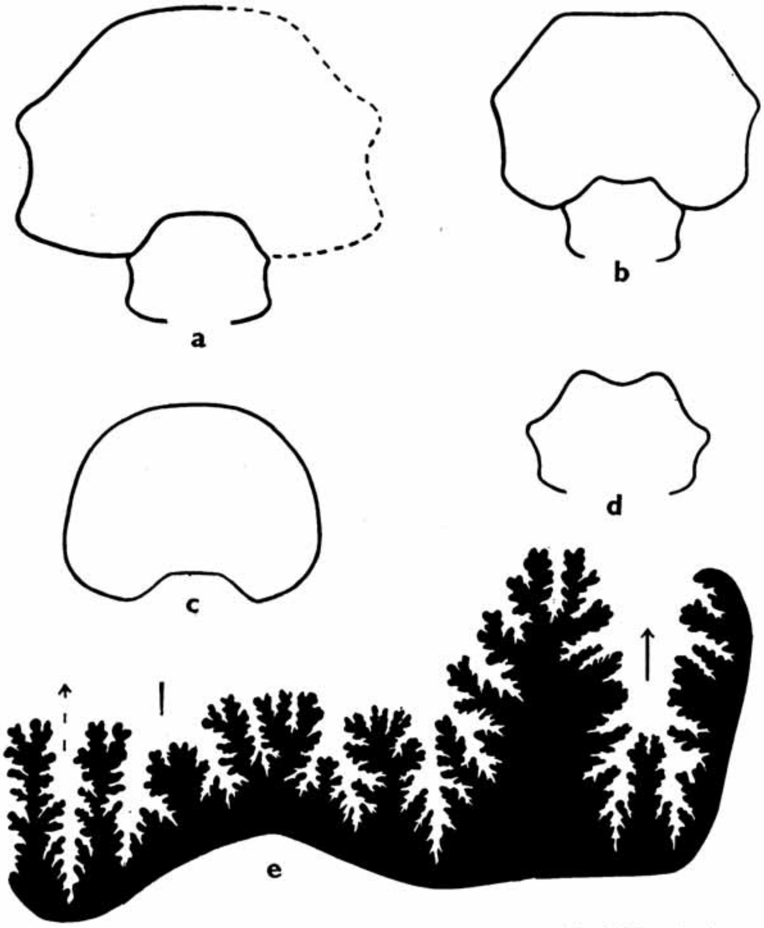
Figs. 3*a*, *b*. *Dufrenoyia transitoria* sp. nov., holotype, base of Carstone, Hunstanton, Norfolk. (BM C 29617.)

Figs. 4*a*, *b*. *Hoplites* (*Isohoplites*) *eodentatus* sp. nov., holotype, Gault–Lower Greensand junction beds (Band III), Arnold's pit, Billington Crossing, Leighton Buzzard, Bedfordshire. (GSM 98602; author's coll.)

Fig. 5. *Limatula sabulosa* sp. nov., holotype, Folkestone Beds, *Farnhamia* horizon, Coxbridge pit, Farnham, Surrey. (GSM 98606; author's coll.) ×5.

Figs. 6*a*–*c*. *Modestella modesta* E. Owen gen. et sp. nov., ventral (*a*), dorsal (*b*), and side (*c*) views of holotype, Folkestone Beds, main *mammillatum* bed, Copt Point, Folkestone, Kent. (GSM Zk 4733; author's coll.) ×1·5.

Diagnosis. Similar to *P. nutfieldensis* (J. Sow.) but with narrower unbilicus, more tardy compression of the whorls, primary ribs more closely set and with primary and secondary ribs in regular alternation to at least 215 mm. diameter.



TEXT-FIG. 14. Whorl-sections and a suture-line of *Cheloniceras*. *a*, *Ch.* (*Ch.*) *parinodum* sp. nov., holotype. *b*, *Ch.* (*Epicheloniceras*) *debile* sp. nov., holotype. *c*, *Ch.* (*E.*) *gracile* sp. nov., holotype. *d*, *e*, *Ch.* (*E.*) *martinioides* sp. nov., topotype (GSM Zm 1728). *a–d* ×1, *e* ×2.

Especially characteristic of Seend, there being several well-preserved examples in the Geological Survey Museum, British Museum, and the Oxford University Museum, all contributed by W. Cunnington and E. C. Davey. A fragment from the Puttenham Beds of Headleywood Farm, north of Headley, Hampshire.

Subfamily ACANTHOHOPLITINAE

Genus NOLANICERAS nov.

Type species. *Hoplites nolani* Seunes 1887, p. 564, pl. 13, figs. 4*a*, *b*, Clansayes horizon, France.

Diagnosis. Similar to compressed *Hypacanthoplites*, with close, flexuous ribbing, but venter rounded, with only a trace of flattening in the young, and no tubercles at the margins at any stage. Lateral tubercles represented only by microscopic pustules in early youth. Suture-line as in *Hypacanthoplites*.

Nolaniceras is an important horizon-marker for the base of the *jacobi* Zone (*nolani* Subzone) and comprises a group of species that lie in the direct line of ancestry of the compressed, closely ribbed *Hypacanthoplites* of the overlying *rubricosus* Subzone. It is represented in Russia by *Parahoplites uhligi* Anthula and *Acanthohoplites bigoti* Sinzow (1907, pl. 4, figs. 19, 20; *non* Seunes); in Algeria by *Parahoplites ouenzaensis* Breistroffer and *P.* (?) *rigidus* Breistroffer; and in Madagascar by forms described by Collignon (1937) under the following names: *Parahoplites* cf. *grossouvrei* Jacob, *P.* aff. *grossouvrei*, *P. hourcqi* Collignon, *Acanthoplites nolani* var. *pygmaea* Sinzow, *A. nolani* var. *subrectangulata* Sinzow. *Immunitoceras* Stoyanow is an allied genus with distinctly flat, angular venter in youth and may not be separable from the early *Hypacanthoplites* of the *rubricosus–subrectangulatus* group.

Genus HYPACANTHOPLITES Spath 1923

Hypacanthoplites milletioides sp. nov.

Plate 83, figs. 1, 2

1875 *Ammonites Milletianus* d'Orb.; Barrois, p. 243 (*pars*).

Holotype. GSM 70559, Folkestone Beds (*milletioides* Subzone), Sandling Junction, near Hythe, Kent (Author's Coll.).

Diagnosis. Aspect of *H. trivialis* Breistroffer, but larger, with coarser, less rigid ribbing. About forty-five ribs at 75 mm. diameter.

I am indebted to Dr. P. Destombes for communicating an assemblage of *Hypacanthoplites* from the Bois-des-Loges horizon, described by Barrois (1875), and which also furnished the type of *H. peroni* (Jacob). These show that d'Orbigny was right to assign

EXPLANATION OF PLATE 84

All figures natural size.

Fig. 1. *Cheloniceras* (*Cheloniceras*) *parinodum* sp. nov., holotype, Ferruginous Sands, top of Group IV, Atherfield, Isle of Wight. T. Matsumoto coll.

Figs. 2*a*, *b*. *Cheloniceras* (*Epicheloniceras*) *martinioides* sp. nov., holotype, Hythe Beds, Boughton Group, Skinner's Quarry, Boughton Mount, Maidstone, Kent. (GSM 98603; author's coll.)

Figs. 3*a*, *b*. *Cheloniceras* (*Epicheloniceras*) *debile* sp. nov., nucleus of holotype, Upper Crioceras Beds, Atherfield, Isle of Wight. (GSM Zm 1952; author's coll.)

Figs. 4*a*, *b*. *Deshayesites fittoni* sp. nov., holotype, Atherfield Clay, 25–30 feet above Perna Bed, Atherfield, Isle of Wight. (GSM Zm 1843; author's coll.)

Figs. 5*a*, *b*. *Deshayesites forbesi* sp. nov., topotype, Atherfield Clay Series (Crackers), Atherfield, Isle of Wight. (SM B 27067.)

Figs. 6, 7. *Cleoniceras* (*Cleoniceras*) *floridum* sp. nov., Folkestone Beds, main *mammillatum* bed, Copt Point, Folkestone, Kent. Both author's coll. 6, Side view of holotype. (GSM 70401.) 7, Ventral view of topotype. (GSM Zk 4866.)

the fossils of this horizon to the Albian rather than to the Aptian as did later authors (e.g. Barrois 1875; Corroy 1925; Breistroffer 1947). A comparable assemblage is found in the Folkestone Beds in the middle of the *tardefurcata* Zone or as derived fossils in the *mammillatum* Zone.

Family HOPLITIDAE

Subfamily HOPLITINAE

Genus HOPLITES Neumayr 1875

Subgenus ISOHOPLITES Casey 1952

Hoplites (*Isohoplites*) *eodentatus* sp. nov.

Plate 83, figs. 4*a*, 4*b*

Holotype. GSM 98602, Lower Greensand/Gault junction Beds, Band III, Arnold's pit, Billington Crossing, Leighton Buzzard, Bedfordshire (Author's Coll.).

Diagnosis. Similar to *H. dentatus* (J. Sow.) in side view but with the ventral aspect of *H.* (*I.*) *steinmanni* (Jacob).

Together with its varieties and allies, this species occurs at the base of the Gault at Folkestone, Chislet Colliery, Westerham, Kent; Reigate, Surrey; Leighton Buzzard, Bedfordshire; Bonchurch, Isle of Wight; and also in the Pay-du-Bray, northern France. Though rare, it is the ammonite best suited as guide fossil for the base of the Middle Albian in the Anglo-French Province.

Genus ANAHOPLITOIDES nov.

Type species. *Saynella splendens* (J. Sowerby) var. *gigas* Sinzow (1915, p. 20) (= *Leymeriella revili* Jacob, Sinzow 1909, pl. 1, figs. 1–4), Lower Albian, *mammillatum* Zone, Mangyshlak, Russia.

Diagnosis. Inner whorls like a costate *Anahoplites* but with the ventral tubercle paired as in *Isohoplites*; outer whorls like those of *Farnhamia*.

This genus is represented in Britain by a unique specimen from the *floridum* Subzone of Oxted, Surrey, *Anahoplitoides* cf. *gigas* (Sinzow), recorded by Wright and Wright (1948, p. 85) as *Anahoplites sp. nov*.

Subfamily CLEONICERATINAE

Genus CLEONICERAS Parona and Bonarelli 1896

Subgenus CLEONICERAS S.S.

Cleoniceras (*Cleoniceras*) *floridum* sp. nov.

Plate 84, figs. 6, 7

1936 *Cleoniceras* cf. *quercifolium* (d'Orb.); Casey, p. 446.
1941 *Cleoniceras* aff. *cleon* (d'Orb.); Brown, p. 10.
1942 *Cleoniceras* aff. *quercifolium* (d'Orbigny); Spath, p. 674.
1943 *Cleoniceras* aff. *quercifolium* (d'Orbigny); Spath, p. 736.
1947 *Cleoniceras* aff. *quercifolium*; Breistroffer, p. 25.
1948 *Cleoniceras* sp. nov.; Wright and Wright, p. 85.

Holotype. GSM 70401, Folkestone Beds, main *mammillatum* bed, Copt Point, Folkestone, Kent (Author's Coll.).

Diagnosis. Phragmocone high, narrowly arched, sides gently convex, widest at the inner third. Umbilicus nearly one-fifth diameter, with low, perpendicular wall, narrowly rounded at the rim. Ten to eleven low, droplet-shaped bullae surround the umbilicus, from each of which radiate fan-wise a bundle of about four falcoid ribs. Ribs form sharp crescents on outer half of sides, but obscured at middle of sides and on siphonal line by zones of incipient smoothness. Body-chamber with scaphitoid tendency; sub-rectangular in section, with broadly rounded venter and coarsened ribbing which forms chevrons on the venter. Suture-line with shallow, asymmetrical first lateral lobe.

Well represented at Folkestone, Westerham, and Oxted; characteristic of an horizon intermediate between the *kitchini* and *raulinianus* Subzones of the *mammillatum* Zone.

PROBLEMATICA

Genus HALLIMONDIA nov.

Type species. *Hallimondia fasciculata* gen. et sp. nov., Upper Aptian (Sandgate Beds), Surrey.

Diagnosis. Bundles of split tubes or troughs apparently growing upwards from a common origin; each trough about $\frac{1}{2}$ inch in diameter and with walls up to $\frac{1}{8}$ inch thick composed of concentric wavy laminae of a weakly birefringent material, probably originally carbonate. Habitat marine.

Hallimondia fasciculata gen. et sp. nov.

Plate 79, fig. 3

Holotype. GSM Zk 3960–61, Sandgate Beds, Cockley Quarry, Nutfield, Surrey (A. G. Davis Coll.).

Diagnosis. Troughs averaging 12 mm. in diameter, roughly semicircular in cross-section, and 40 cm. or more in length. Straight, approximate and parallel throughout most of their length, but diverging slightly at the distal end and curving under at the proximal end and apparently tapering to a common origin, like a bunch of bananas.

Briefly described by Dines and Hallimond (*in* Dines and Edmunds 1933, pp. 63, 64), this organism is not uncommon in the limestones associated with the fuller's earth seams in the Nutfield quarries, where it forms the nuclei of phosphatic nodules. The structure resembles a sheaf of curled rushes but does not appear to be of plant origin. Phosphatization has destroyed any possible clues that the original mineralization gave to its systematic position.

Genus PETROMONILE nov.

Type species. *Siphonia* (*or Spongites*) *benstedii* Bensted, Upper Aptian (Hythe Beds, Boughton Group), Maidstone, Kent. Lectotype here selected: the original of Bensted 1862, pl. 18, fig. 3, in the Maidstone Museum.

Diagnosis. Irregularly branched stems, averaging 10 mm. diameter, periodically lobed so as to resemble a string of beads.

These curious structures were described by Bensted (1862, pp. 335–6, pl. 17, 18) as sponges, partly, it seems, because spicules were seen to be concentrated in parts of the organism. Examination of a set of specimens in the Maidstone Museum, including the originals of some of Bensted's figures, shows a random distribution of spicules in both organism and matrix and the sponge affinities must be considered doubtful. A fucoid origin is a possibility.

FAUNAL AND FLORAL LISTS

Conclusion of the descriptive part of this paper brings us to the point where we may take stock of the fauna and flora of the Lower Greensand and attempt to set it out on a zonal basis. Material for the following lists has been brought together from many sources, but their nucleus is the collections in the British Museum (Natural History), the Geological Survey Museum, and the Sedgwick Museum, Cambridge. In addition I have worked over the material in a score of provincial museums and private collections: the most important in the former category is the Museum of Isle of Wight Geology, Sandown; in the latter category, the collection of the Wright brothers. The results of my own personal field-work are incorporated in the collections of the Geological Survey Museum. In matters of nomenclature I have undertaken original revisionary work only in the Mollusca; the rest has been culled from the literature, British and foreign. Microzoa are not listed. No work has been done on foraminifera and ostracoda since Chapman (1894) and Wright (1905) and the mere repetition of their lists (which include many names of Recent species) without critical examination of the originals is felt to be pointless. Many species are here recorded from the Lower Greensand for the first time: doubtless there are as many omissions. The following abbreviations are used for the zones:

M = *martinioides* m = *mammillatum*
B = *bowerbanki* T = *tardefurcata*
D = *deshayesi* J = *jacobi*
f = *forbesi* N = *nutfieldensis*
F = *fissicostatus*

PLANTAE

Class ALGAE

Girvanella intermedia (Wethered) B, M.

Class FUNGI

Unidentified ascomycetes parasitic in coniferous wood T.

Class FILICINAE

Weichselia reticulata (Stokes & Webb) (= *Lonchopteris mantelli* Brongniart) D-N.
Protopteris fibrosa (Stenzel) M.
Tempskya erosa (Stokes, Webb & Mantell) (= *T. schimperi* Auctt.) ?F.

Class GYMNOSPERMAE

Sub-class CYCADOPHYTA

Bennettites gibsonianus Carruthers J.
— *allchini* Stopes ?M.
— *maximus* Carruthers J.
— *inclusus* Carruthers ?F.
Cycadeoidea yatesi Carruthers (= *Yatesia morrisi* Carruthers) ?T.
— *buzzardensis* Stopes ?T.
Cycadeostrobus walkeri Carruthers ?F.
Colymbetes edwardsi Stopes ?

Sub-class CONIFERALES

Sequoia giganteoides Stopes J.
Protopiceoxylon edwardsi Stopes J.
Pityoxylon sewardii Stopes ?J, ?T.
— *woodwardi* Stopes ?N.
— *sp.* B, M.
Pseudoaraucaria benstedii (Stopes) M.
Pityostrobus sussexiensis (Mantell) J.
— *benstedi* (Mantell) M.
— *patens* (Carruthers) M.
— *cylindroides* (Gardner) ?F, ?N.
— *pottoniensis* (Gardner) ?F, ?N.
— *jacksoni* Creber J.
Kaidacarpum minus Carruthers ?F, ?N.
Cedrostrobus leckenbyi (Carruthers) J.
— *mantelli* (Carruthers) M.
Cedroxylon maidstonense Stopes M.
— *pottoniense* Stopes ?F, ?N.
Abietites cf. *solmsi* (Seward) M.
Cupressinoxylon vectense Barber J.
— *luccombense* (Stopes) J.
— *cryptomerioides* Stopes M.
— *hortii* Stopes N.
— *sp.* ?N.
Taxoxylon anglicum Stopes ?N.
Podocarpoxylon woburnense Stopes ?N.
— *bedfordense* Stopes ?N.

Podocarpoxylon gothani Stopes J.
— *solmsi* Stopes J.
Vectia luccombensis Stopes J.
Unidentified coniferous wood F-m.

Class ANGIOSPERMAE

Cantia arborescens Stopes ?J, ?T.
Woburnia porosa Stopes ?N.
Sabulia scottii Stopes ?N.
Hythia elgari Stopes ?M.
Aptiana radiata Stopes ?J.

INVERTEBRATA

Phylum PORIFERA

Class DEMOSPONGIA

Mastosia neocomiensis Hinde B, M.
Chenendopora sp. B, M.
Undetermined Hallirhoidae B, M. T.
Doryderma cf. *benetti* Hinde T.
— *sp.* B.
Stelletta cf. *inclusa* Hinde J, T.
Reniera gracilis Hinde B, M.
— *zitteli* Počta B, M.
Axinella gracilis Hinde B, M.
— *dispersa* Hinde B, M.
— *stylus* Hinde B, M.
Spirastrella neocomiensis Hinde M.
Monilites haldonensis Carter M.
Dirrhopalum neocomiensis Hinde B, M.
Geodites carteri Hinde B, M. T, m.
— *robustus* Hinde B, M, T, m.
— *audax* Hinde B, M.
— *obtusus* Hinde T, m.
— *politus* Hinde B, M, T.
— *pusillus* Hinde B, M.
— *haldonensis* Carter T.
— *divergens* Hinde B, M.
— *wrighti* Hinde B, M, ?N.
— *planus* Hinde B, M.
Stellettites? T.
Tethyopsis haldonensis Carter B, M, T.
Pachastrella quadriradiata Carter M.
Cliona cf. *cretacea* (Portlock) D-m.
— cf. *microtuberum* Stephenson J-m.
— cf. *retiformis* Stephenson J-m.
— *sp. nov.*? J.

Class HEXACTINELLIDA

Plocoscyphia pertusa Geinitz N.
— cf. *labrosa* (T. Smith) T.
— cf. *fenestrata* (T. Smith) T.
— *sp.* J, T.
Stauractinella sp. ?M.
Tremabolites sp. T, m.

Class CALCAREA

Peronidella ramosa (Roemer) N.
— *gillieroni* (de Loriol) N.
— *prolifera* (Hinde) N.
Barroisia anastomosans (Mantell) N.
— *irregularis* (Hinde) N.
— *clavata* (Keeping) N.
Elasmocoelia crassa (Fromentel) N.
— *mantelli* Hinde N.
Corynella foraminosa (Goldfuss) N.
Synopella pulvinaria (Goldfuss) N.
Oculospongia dilatata (Roemer) N.
Raphidonema contortum Hinde N.
— *porcatum* (Sharpe) N.
— *pustulatum* Hinde N.
— *macropora* (Sharpe) N.
— *farringdonense* (Sharpe) N.
— *sp.* T.

Phylum COELENTERATA

Class HYDROZOA

Lonsda contortuplicata (Lonsdale) F.
Burgundia sp. N.

Class ANTHOZOA

Oculina hobleyi Thomas B.
Holocystis elegans (Lonsdale) F.
Turbinoseris defromenteli Duncan F.
Astrocoenia sp. N.
Isastraea morrisi Duncan N.
— *sp.* F.
Thamnasteria sp. F.
Placosmilia neocomiensis (de Fromentel) F.
Smilotrochus austeni Edwards & Haime F.
Discocyathus orbignyanus (Edwards & Haime) F.
— *fittoni* (Edwards & Haime) m.
Trochocyathus meyeri Duncan N.
— *conulus* (Phillips) m.
— cf. *harveyanus* Edwards & Haime m.

Phylum ECHINODERMATA

Class CRINOIDEA

Isocrinus fittoni (Austen) T.
— *sp.* f-J.
Torynocrinus rugosus Seeley T.

Class OPHIUROIDEA

Ophiurites sp. T.

Class ASTEROIDEA

Lophidiaster ornatus Spencer T.
— *sp.* f.
Comptonia sp. f.
Gen. et sp. indet. D, B, N, J, T.

Class ECHINOIDEA

'*Cidaris*' *faringdonensis* Wright N.
— *coxwellensis* Hawkins N.
— *sp.* T, m
Tetragramma rotulare (Agassiz) N.
— *malbosi* (Agassiz & Desor) D, B.
Trochotiara fittoni (Wright) f, N.
Polydiadema cf. *wiltshirei* (Wright) T, m.
Salenia rugosa d'Archiac T.
— *hieroglyphica* Keeping N.
— *prestensis* Desor N.
Hyposalenia wrighti (Desor) F-N.
— *lardyi* (Desor) N.
— *stellulata* (Agassiz) N.
— *studeri* (Agassiz) T.
— *sp.* F.
Goniophorus lorioli Lambert & Thiéry T.
Discoidea decorata Desor D, B.
— cf. *subuculus* Leske T, m.
Pyrina desmoulinsii d'Archiac T.
Conulopyrina anomala Hawkins T.
Catopygus vectensis Wright N.
— *columbarius* (Lamarck) N-T.
— *switensis* Desor B.
Goniopygus delphinensis Gras N.
Plagiochasma faringdonense (Wright) N.
— *coxwellense* Melville N.
Toxaster murchisonianus (Mantell) T, m.
— *complanatus* Agassiz F.
— (*Pliotoxaster*) *fittoni* (Forbes) F-N.
— (—) *renevieri* (Wright) N.
Phyllobrissus fittoni (Wright) M, N.
— *artesianus* Hawkins T, m.
— *circeleti* (Desor) m.
Nucleolites lacunosus Goldfuss T.
Hemiaster sp. T.
Holaster benstedi (Forbes) B, M.
— *wrighti* Lambert N.
— (*Labrotaxis*) *cantianus* Casey J-m.

Phylum ANNELIDA

Serpula antiquata J. de C. Sowerby D-m.
— *filiformis* J. de C. Sowerby F-m.
— *articulata* J. de C. Sowerby T.
— *plexus* J. de C. Sowerby M, m.
— *gordialis* (Schlotheim) m.
— cf. *adnata* Wade T.
— *spp.* F-m.
Rotularia polygonalis (J. de C. Sowerby) D-N.
— *concava* (J. Sowerby) N-m.
'*Terebella*' *sp.* T.

Phylum POLYZOA

Stomatopora calypso d'Orbigny N, J.
Cellulipora spissa (Gregory) N.
Proboscina crassa (Roemer) N.
— — var. *divaricata* (d'Orbigny) N.
— *radiolitorum* d'Orbigny N.
— *ricordeauana* d'Orbigny N.
— *virgula* d'Orbigny N.
— *depressa* d'Orbigny N.
— *coarctata* Canu & Bassler N.
— *ziczac* d'Orbigny N.
— *faringdonensis* Canu & Bassler N.
— *filifera* Canu & Bassler N.
— *grandipora* Canu & Bassler N.
— *parvula* Canu & Bassler N.
— *pulchella* de Loriol N.
— (*Reptomultisparsa*) *tenella* (de Loriol) N.
Clinopora quadripartita Canu & Bassler N.
Heteropora nummularia Canu & Bassler N.
— *keepingi* Gregory N.
— *clavata* Kade N.
— *michelini* (d'Orbigny) ?N, T.
— *buskana* (de Loriol) N.
Multicrescis mammillosa Canu & Bassler N.
Seminodicrescis nodosa d'Orbigny N.
Ceriopora farringdonensis Gregory N.
— *collis* (d'Orbigny) N.
— *confusa* (de Loriol) N.
— *ramulosa* (Michelin) m.
— *dimorphocella* Canu & Bassler N.
— *spongioides* Canu & Bassler N.
Reptomulticava fungiformis Gregory B, N.
— *lobosa* (Keeping) N.
— *nodosa* (Keeping) N.
Neuropora micropora Canu & Bassler N.
— *tenuinervosa* Canu & Bassler N.
Neuroporella hemispherica Canu & Bassler N.
Microecia cornucopia (d'Orbigny) N.
Trigonoecia haimeana (de Loriol) N.
Cardioecia faringdonensis Canu & Bassler N.
— *pauper* Canu & Bassler N.
Notoplagioecia faringdonensis Canu & Bassler N.
Cea granulata Canu & Bassler N.
Diaperoecia (?) *simplex* Canu & Bassler N.
— *orbifera* Canu & Bassler N.
Plethopora aptensis Canu & Bassler N.
Multigalea canui (Gregory) N.
— *marginata* Canu & Bassler N.
Tholopora virgulosa (Gregory) N.
— *colligata* (Gregory) N.
— *thomasi* Pitt N.
Radiopora tuberculata (d'Orbigny) N.
— *neocomiensis* (d'Orbigny) N.
Lobosoecia semiclausa (Michelin) N.
Meliceritites haimeana (d'Orbigny) N, J, T.
— *transversa* Canu & Bassler N.
— *cunningtoni* (Gregory) N.

Meliceritites semiclausa Gregory N.
— (?) *upwarensis* Keeping N.
Chisma furcillata Lonsdale f-N.
Choristopetalum impar Lonsdale F-J.
Clausa cranei Canu & Bassler N.
— *zonifera* Canu & Bassler N.
Reptoclausa denticulata Canu & Bassler N.
— *hagenowi* (Sharpe) N.
Tretocycloecia (?) *multiporosa* Canu & Bassler N.
Berenicea gracilis (Milne-Edwards) F.
— *densa* Canu & Bassler N.
Laterocavea dutempleana d'Orbigny N.
— *intermedia* Canu & Bassler N.
Petalopora cunningtoni Gregory N, J.
Siphodictyon gracile Lonsdale F, D-T.
— *irregulare* Canu & Bassler N.
Sparsicavea irregularis d'Orbigny N.
Homoesolen pinnatus (Roemer) m.
Echinocava raulini (Michelin) N, m.
Inversaria orbicularis Gregory T.
Zonatula brydonei Gregory N.
Multizonopora arborea (Kock & Dunker) N.
Discocavea cf. *neocomiensis* d'Orbigny N.
Semimulticavea variolata Gregory N.
Graysonia anglica sp. nov. T.

Phylum BRACHIOPODA

Class INARTICULATA

Lingula truncata J. de C. Sowerby D-J.
— *sp.* T.
Discinisca sp. nov. B.
Bifolium faringdonense (Davidson) N.

Class ARTICULATA

Rhombothyris extensa (Meyer) N.
— *microtrema* (Walker) N.
— *meyeri* (Walker) N.
— *conica* Middlemiss N.
Platythyris comptonensis Middlemiss M, N.
— *minor* Middlemiss N.
Sellithyris sella (J. de C. Sowerby) F-M.
— — *shanklinensis* Middlemiss N.
— *upwarensis* (Walker) N.
— *coxwellensis* Middlemiss N.
Cyrtothyris cyrta (Walker) ?F, B-N.
— *uniplicata* (Walker) B-N.
— *cantabridgiensis* (Walker) ?B, N.
— *seeleyi* (Walker) N.
— *dallasi* (Walker) N.
Praelongithyris praelongiforma Middlemiss ?B, M, N.
— *lankesteri* (Walker) N.
Rectithyris depressa (Lamarck) T.
Rectithyris shenleyensis (Lamplugh & Walker) T.
'*Terebratula*' *capillata* d'Archiac T.
— *dutempleana* d'Orbigny T, m.
— *gigantea* Lamplugh & Walker T.
— *moutoniana* d'Orbigny var. T.
— *boubei* d'Archiac T.
— *ovata* J. Sowerby T.
'*Ornithella*' *juddi* (Walker) N.
— *tamarindus* (J. de C. Sowerby) N.
— cf. *tamarindus* (J. de C. Sowerby) T.
— *pseudojurensis* (Auctt. *non* Leymerie sp.) N, T.
— *wanklyni* (Walker) N.
— *morrisi* (Meyer) N.
— *celtica* (Morris) B-N.
Aulacothyris woodwardi (Walker) N.
Zeilleria convexiformis Lamplugh & Walker T.
Modestella modesta Owen gen et. sp. nov. m.
— *sp. nov.* T.
Magas latistriata Lamplugh & Walker T.
— *orthiformis* (d'Archiac) T.
'*Terebratella*' *hercynica* (Schloenbach) T.
— *davidsoni* Meyer N.
— *keepingi* Walker N.
Gemmarcula aurea Elliott M, N.
— *menardi* (Lamarck) T.
— — var. *pterygotos* (Lamplugh & Walker) T.
Arenaciarcula fittoni (Meyer) M. N.
Oblongarcula oblonga (J. de C. Sowerby) D-N.
Trifidarcula trifida (Meyer) N.
Terebrirostra arduennensis d'Orbigny (= *T. lyra* var. *incurvirostrum* Lamplugh & Walker) T.
Kingena lima (Defrance) T.
— *arenosa* (d'Archiac) T.
— *newtoni* Lamplugh & Walker T.
— *spinulosa* (Morris) m.
Terebratulina triangularis Etheridge T.
— *elongata* Davidson N.
Cyclothyris latissima (J. de C. Sowerby) N-T.
Sulcirhynchia hythensis Owen F-M.
Lamellirhynchia caseyi Owen N, J.
'*Rhynchonella*' *gibbsiana* (J. de C. Sowerby) T.
— *leightonensis* Lamplugh & Walker T, m.
— *shenleyensis* Lamplugh & Walker T.
— *grasiana* d'Orbigny T.
— *lineolata* (Phillips) T.
— *carteri* Davidson T.
— *mirabilis* Lamplugh & Walker T.
— *dimidiata* (J. Sowerby) T.
— *antidichotoma* Buvignier N, T.
— *depressa* (J. de C. Sowerby) N.
— *parvirostris* (J. de C. Sowerby) N.
— *cantabridgensis* Davidson N.
— *upwarensis* Davidson N.
— *deluci* (Pictet) J.
— *nuciformis* (J. de C. Sowerby) N.

Phylum MOLLUSCA

Class LAMELLIBRANCHIA

Nuculana scapha (d'Orbigny) F, f.
— *spathulata* (Forbes) f.
— *solea* (d'Orbigny) m.
Mesosaccella mariae (d'Orbigny) T, m.
Nucula meyeri Gardner F, f, N.
— (*Pectinucula*) *pectinata* J. Sowerby m.
— (—) *arduennensis* d'Orbigny J.
— (*Leionucula*) *planata* Deshayes F-B, J.
— (—) *albensis* d'Orbigny m.
— (—) *ovata* Mantell m.
Acila (*Truncacila*) *bivirgata* (J. de C. Sowerby) m.
Anomia pseudoradiata (d'Orbigny) F-J.
— *laevigata* J. de C. Sowerby f-M.
— *convexa* J. de C. Sowerby N.
— *sp*. (Woods) f.
Arca dupiniana d'Orbigny F-T.
— *sanctae-crucis* Pictet & Campiche F-N.
Eonavicula carteroni (d'Orbigny) F, N.
Barbatia marullensis (d'Orbigny) N, J.
— cf. *baudoniana* (Cotteau) B.
Scaphula ? austeni (Forbes) F, f.
Nanonavis carinata (J. Sowerby) N-m.
Aptolinter aptiensis (Pictet & Campiche) F-T.
Cucullaea nana Leymerie m.
— *tealli* nom. nov. (= *Pectunculus obliquus* Keeping) N.
— *fittoni* Pictet & Campiche f.
— *cornueliana* d'Orbigny f, B, N.
— (*Idonearca*) *glabra* Parkinson N-m.
— (—) *obesa* Pictet & Campiche m.
Cryptochasma ovale gen. et sp. nov. N.
Noramya forbesi (Pictet & Campiche) F.
— *gabrielis* (Leymerie) F.
Isoarca obesa (d'Orbigny) m.
Glycymeris marullensis (Leymerie) B, N.
— (*Glycymerita*) *sublaevis* (J. de C. Sowerby) N-T.
— (—) *umbonata* (J. Sowerby) T.
Limopsis albensis Woods J.
— *dolomitica* sp. nov. N.
Trigonia carinata Agassiz F-B.
Pterotrigonia vectiana (Lycett) F.
— *mantelli* sp. nov. (s.s.) M-m.
— — *anterior* subsp. nov. D, B.
— *caudata* (Agassiz) F, f.
— *etheridgei* (Lycett) F, f.
Linotrigonia (*Linotrigonia*) *fittoni* (Deshayes) m.
— (*Oistotrigonia*) *ornata* (d'Orbigny) F, D-M.
— (—) *upwarensis* (Lycett) N, J.
— (—) *archiaciana* (d'Orbigny) m.
Yaadia nodosa (J. de C. Sowerby) F-J.
Myoconcha delta sp. nov. N.
Mytilus cf. *tornacensis* d'Archiac N.
Modiolus aequalis J. Sowerby F-m.
— *reversus* (J. de C. Sowerby) T, m.
— *ligeriensis* (d'Orbigny) F.
— *subsimplex* (d'Orbigny) F-m.
— *rugosus* (Roemer) f.
— *undulatus* (Forbes) f.
Brachidontes vectiensis (Woods) F, f.
Arcoperna bella (J. de C. Sowerby) F-J.
Septifer sublineatus (d'Orbigny) F, D-m.
Cuneolus lanceolatus (J. de C. Sowerby) F-m.
Spondylus roemeri Deshayes F.
— *guttatus* (Sharpe) N.
— *gibbosus* d'Orbigny m.
— *striatus* (J. Sowerby) N-T.
Plicatula placunea Lamarck D, B.
— *carteroniana* d'Orbigny B-N, T.
— *aequicostata* Keeping N.
Plicatula inaequidens Sharpe N.
— *gurgitis* Pictet & Roux m.
— *inflata* J. de C. Sowerby T, m.
Diploschiza sp. J-m.
Entolium orbiculare (J. Sowerby) F-m.
Camptonectes cottaldinus (d'Orbigny) F, D, B.
— *striato-punctatus* (Roemer) F, T.
Chlamys elongata (Lamarck) m.
— *robinaldina* (d'Orbigny) F-m.
— *subacuta* (Lamarck) T.
Neithea (*Neitheops*) *quinquecostata* (J. Sowerby) F-m.
— (—) *syriaca* (Conrad) (= *Pecten morrisi* Pictet & Renevier) F-B.
— (—) *atava* (Roemer) N.
Eopecten rhodani (Pictet & Roux) m.
Prohinnites favrinus (Pictet & Roux) F, D, B.
Plagiostoma globosa (J. de C. Sowerby) T, m.
— *albensis* (d'Orbigny) J, T, m.
— cf. *orbignyana* (Matheron) N.
Acesta longa (Roemer) N-T.
Pseudolimea parallela (J. de C. Sowerby) F, D-m.
— *gaultina* (Woods) T, m.
— *farringdonensis* (Sharpe) N.
— *elongata* (J. de C. Sowerby) m.
— cf. *cantabrigiensis* (Woods) J.
Ctenoides cf. *rapa* (d'Orbigny) T.
Limatula tombeckiana (d'Orbigny) D, B, N.
— *dupiniana* (d'Orbigny) F, D-N.
— *sabulosa* sp. nov. T, m.
Oxytoma pectinatum (J. de C. Sowerby) D-m.
— *cornuelianum* (d'Orbigny) N.
Pseudoptera subdepressa (d'Orbigny) F, f.
Aucellina sp. T.
Gervillia linguloides Forbes f.
Bakevellia rostrata (J. de C. Sowerby) N, J.

Gervillella sublanceolata (d'Orbigny) F-J.
Gervillaria alaeformis (J. Sowerby) F-B.
Ensigervilleia forbesiana (d'Orbigny) F-J, m.
Mulletia mulleti (Deshayes) F.
Isognomon ricordeanus (d'Orbigny) F.
— *raulinianus* (d'Orbigny) m.
Inoceramus neocomiensis d'Orbigny D-N.
— *salomoni* d'Orbigny m.
— *coptensis* sp. nov. T, m.
Pinna (*Pinna*) *robinaldina* d'Orbigny F-J.
— (*Stegoconcha*) cf. *iburgensis* Weerth F.
— (—) cf. *hombresi* Pictet & Campiche f.
— (—) cf. *gervaisii* Dumas D, B.
Astarte cantabrigiensis Woods N.
— (*Neocrassina*) *obovata* J. de C. Sowerby F, D.
Freiastarte subcostata (d'Orbigny) F, f, D.
— *praetypica* sp. nov. J.
Eriphyla striata (J. de C. Sowerby) J.
— *concinna* (J. de C. Sowerby) J.
— *upwarensis* (Woods) N.
— *pseudostriata* (d'Orbigny) B, N.
Opis (*Trigonopis*) *neocomiensis* d'Orbigny N.
— (—) cf. *dubisiensis* Pictet & Campiche F.
Ptychomya robinaldina (d'Orbigny) F-N.
Seendia saxoneti (Pictet & Roux) N.
Disparilia disparilis (d'Orbigny) F.
Pachythaerus tealli sp. nov. N, T.
Anthonya cantiana Woods N-m.
— *woodsi* sp. nov. f.
Mediraon subacutum (d'Orbigny) F, f.
— *sulcatum* sp. nov. F, f.
Protodonax minutissimus (Whitfield) N.
Linearia subconcentrica (d'Orbigny) F, f.
— *cornea* sp. nov. f.
— cf. *olea* Vokes N.
— *rauliniana* (d'Orbigny) m.
Palaeomoera inaequalis (J. de C. Sowerby) J, T.
Scittila nasuta gen. et sp. nov. F, f.
— — var. *radiata* nov. f.
Icanotia pennula sp. nov. F.
— cf. *siliqua* sp. nov. J.
Senis wharburtoni (Forbes) F-m.
Geltena meyeri sp. nov. N.
Fenestricardita fenestrata (Forbes) F, f.
Trapezicardita squamosa (Keeping) N, J.
— *arcadiformis* (Keeping) N.
Pseudocardia cf. *dupiniana* (d'Orbigny) f.
— *tenuicosta* (J. de C. Sowerby) T, m.
— — var. *constanti* (d'Orbigny) m.
— — var. *rotundata* (Pictet & Roux) m.
— *sp. nov.* N, J.
Cardita upwarensis Woods N.
— *sp. nov.* (Woods, pl. xviii, fig. 6) F.
Lucina cornueliana d'Orbigny D-T.
— *tenera* (J. de C. Sowerby) J.
Lucina arduennensis d'Orbigny T.
Sphaera corrugata J. Sowerby F-N.
Mutiella canaliculata (J. de C. Sowerby) T.
Mactromya vectensis (Woods) F, f, N.
— *compressa* (Woods) f.
— *ringmeriensis* (Mantell) T, m.
Thetironia minor (J. de C. Sowerby) F-m.
— *laevigata* (J. Sowerby) m.
Protocardia anglica Woods f.
— *sphaeroidea* (Forbes) F.
Nemocardium (*Pratulum*) *ibbetsoni* (Forbes) F, f, N.
Granocardium cf. *proboscideum* (J. de C. Sowerby) F.
Cardium cottaldinum d'Orbigny N.
Eomiodon cf. *libanoticus* (Fraas) f.
Venilicardia saussuri (Brongniart).
— *protensa* (Woods) F, f.
— *anglica* (Woods) f.
— *sowerbyi* (Woods) D-N.
— *inornata* (d'Orbigny) D, B.
Epicyprina harrisoni sp. nov. J, T.
Proveniella meyeri (Woods) F.
— *regularis* (d'Orbigny) N.
— *quadrata* (d'Orbigny) m.
— *ervyensis* (d'Orbigny) m.
— *rosacea* sp. nov. F, ?f.
Vectianella vectiana (Forbes) f.
Isocyprina sedgwicki (Keeping) N.
'*Cyprina*' *obtusa* Keeping N.
Tortarctica similis (J. de C. Sowerby) J-m.
— *cordiformis* (d'Orbigny) m.
Lithophaga phosphatica (Keeping) N.
— *oblonga* (d'Orbigny) M.
— *spp.* N.
Resatrix (*Resatrix*) *dolabra* Casey F, f.
— (—) *neocomiensis* (d'Orbigny) F.
— (—) *woodsi* Casey f.
— (—) *parva* (J. Sowerby) f-N.
— (—) *hythensis* Casey D, B, M.
— (*Dosiniopsella*) *cantiana* Casey J.
— (—) *vibrayeana* (d'Orbigny) m.
— (*Vectorbis*) *vectensis* (Forbes) f.
Pseudaphrodina ricordeana (d'Orbigny) F-N.
— *brongniartina* (Leymerie) F, f.
— *elongata* Casey F.
Filosina cf. *gregaria* Casey f.
Toucasia lonsdalii (J. de C. Sowerby) N.
Gyropleura sp. N, T.
Parmicorbula striatula (J. de C. Sowerby) F-m.
— *elegantula* (d'Orbigny) f, J.
Caestocorbula olivae (Whitfield) f.
— *sp.* (Woods pl. 34, fig. 13) f.
Cuneocorbula arkelli sp. nov. f.
Panopea gurgitis (Brongniart) F-m.

Panopea gurgitis var. *plicata* J. de C. Sowerby F-m.
— — var. *neocomiensis* (Leymerie) F-B, m.
— *mandibula* (J. Sowerby) F-m.
— cf. *meyeri* Woods D.
Martesia prisca (J. de C. Sowerby) B-m.
Opertochasma constrictum (Phillips) D-M, J, T.
Goniochasma dallasi (Walker) N.
Terebrimya gaultina (Woods) T, m.
Xylophagella zonata sp. nov. m.
Plectomya anglica Woods f.
— *marullensis* (d'Orbigny) f.
Cercomya gurgitis Pictet & Campiche f.
Ceratomya (?) ornata (Forbes) ?F.
Thracia rotundata (J. de C. Sowerby) D, B.
Periplomya simplex (d'Orbigny) T, m.
— *robinaldina* (d'Orbigny) F, f.
Pholadomya cornueliana (d'Orbigny) F, f.
— *gigantea* (J. de C. Sowerby) F-D.
— *martini* (Forbes) F-N.
— *fabrina* d'Orbigny m.
Myopholas cf. *semicostata* (Agassiz) f, N.
Girardotia sp. N.
Goniomya archiaci (Pictet & Renevier) f.
— *sp.* J, T.
Lopha diluviana (Linné) F-m.
Ostrea (*Liostrea*) *leymerii* Leymerie F, D, m.
— (—) *cunabula* Seeley T.
— (—) *vesicularis* Lamarck T, m.
— (—) *walkeri* Keeping N.
Gryphaeostrea canaliculata (J. Sowerby) N-m.
Exogyra latissima (Lamarck) (= *E. sinuata* J. Sow. sp.) F-m.
— *conica* (J. de C. Sowerby).
— *tuberculifera* Koch & Dunker F-J.
— *arduennensis* (d'Orbigny) m.

Class GASTROPODA

Acmaea formosa (Gardner) N.
— *sp.* T.
Helcion meyeri Gardner N.
Anisomyon vectis Gardner f.
Scurria calyptraeformis Gardner N.
— *depressa* Gardner N.
Scurriopsis (*Dietrichiella*) *plana* (Gardner) F.
Loxotoma neocomiense (d'Orbigny) F, f, N.
— *valangiense* Pictet & Campiche F.
— *puncturellum* Gardner F, f.
Brunonia gigantea (Gardner) B.
Hipponyx neocomiensis Gardner B.
Ringinella albensis (d'Orbigny) N.
— *subalbensis* (d'Orbigny) f.
— *lacryma* (Michelin) m.
— *inflata* (d'Orbigny) m.
Ovactaeonina forbesiana (d'Orbigny) F, f, D.
Sulcoactaeon marginatus (Deshayes) f.
Tornatellaea aptiensis (Pictet & Campiche) F, f, D.
— *marullensis* (d'Orbigny) F, f, D.
Actaeonella (*Trochactaeon*) cf. *oliviformis* Coquand f.
— (*Cylindritella*) cf. *verneuilli* (Vilanova) f.
Cinulia globosa (d'Orbigny) F.
Anchura carinella (d'Orbigny) m.
— (*Perissoptera*) *parkinsoni* (Mantell) m.
— (—) cf. *parkinsoni* (Mantell) N, J.
— (—) *glabra* (Forbes) F, f.
— (—) *robinaldina* (d'Orbigny) F-N.
— (—) *spartacus* (Coquand) f.
Dimorphosoma calcaratum (J. de C. Sowerby) m.
— *ancylochila* (Gardner) f.
— *kinclispira* (Gardner) f.
— *vectianum* (Gardner) f.
— *pleurospira* (Gardner) F.
Tessarolax moreausianum (d'Orbigny) F, f, N.
— *fittoni* (Forbes) f.
— *becklesii* (Mantell) f.
— *gardneri* (Keeping) N.
— *retusum* (J. de C. Sowerby) m.
Tridactylus walkeri (Gardner) N.
Pterocella macrostoma (J. de C. Sowerby) F.
Arrhoges (*Monocuphus*) *dupinianus* (d'Orbigny) F.
Tylostoma rochatianum (d'Orbigny) F, f.
— *fittoni* (d'Orbigny) f.
— *gaultinum* Pictet & Campiche m.
Confusiscala dupininiana (d'Orbigny) T, m.
— *cruciana* (Pictet & Campiche) F.
— *ischyra* (Gardner) N.
Claviscala clementina (Michelin) T, m.
— *canaliculata* (d'Orbigny) F.
— *ricordeana* (d'Orbigny) N.
'*Scalaria*' *keepingi* Gardner N.
— *kalospira* Gardner ?N.
— *meyeri* Gardner F.
— *cerithioides* Gardner N.
Cassiope lujani (de Verneuil) f.
— var. *crassa* Coquand f.
— *helvetica* (Pictet & Renevier) f.
— *pizcuetana* (Vilanova) f.
— — var. cf. *renevieri* Coquand f.
Uchauxia forbesiana (d'Orbigny) (= *Cerithium phillipsi* Forbes *non* Leymerie) F, f.
— *albensis* (d'Orbigny) F.
Mesalia (*Bathraspira*) *tecta* (d'Orbigny) m.
— (—) *neocomiensis* (d'Orbigny) F, f, M, N.
Metacerithium trimonile (Michelin) m.
— *campichei* Cossmann f.
Gymnocerithium nostradami (Coquand) f.
— *tumidum* (Keeping) N.

Gymnocerithium marollinum (d'Orbigny) N.
Atresius lallierianus (d'Orbigny) m.
— *fittoni* (d'Orbigny) F, f, N.
Circocerithium aptiense (d'Orbigny) D.
Nerineopsis excavata (Buvignier) m.
'*Cerithium*' *aculeatum* Forbes F.
— *subattenuatum* d'Orbigny (= *C. attenuatum* Forbes *non* J. de C. Sowerby sp.) f.
— *turriculatum* Forbes f.
— *clementinum* d'Orbigny f.
Pseudomelania melanoides (Deshayes) N.
— *sp. nov.* f.
Brightonia turris gen. et sp. nov. N.
— *sandlingensis* gen. et sp. nov. m.
Eulima albensis d'Orbigny F.
Columbellina neocomiensis (d'Orbigny) F.
— *sp.* m.
Neptunella cf. *espaillaci* (d'Orbigny) T.
Buccinofusus clementinus (d'Orbigny) m.
Sipho gaultinus (d'Orbigny) T, m.
Globularia cornueliana (d'Orbigny) F, f, N.
— *sublaevigata* (d'Orbigny) F, f.
— *arduennensis* (d'Orbigny) T, m.
Gyrodes genti (J. Sowerby) N-m.
'*Natica*' *pradoana* Vilanova f.
Neridomus cf. *alcibari* (Coquand) f.
Nerita sp. nov. N.
Neritopsis robineausiana (d'Orbigny) N.
— *sp.* f.
Turritella (*Haustator*) *vibrayeana* d'Orbigny m.
— (—) *raulinianà* d'Orbigny m.
— (—) *dupiniana* d'Orbigny f, N.
— (—) *sp. nov.* J.
Nerinea sp. nov. N.
Pleurotomaria anstedi Forbes M, N.
— *toulmini* Cox D, B.
— *shenleyensis* Cox T.
Leptomaria gibbsi (J. Sowerby) m.
— *billingtonensis* Cox.
Bathrotomaria leightonensis Cox T.
— *atherfieldensis* Cox.
— *ferruginea* (Keeping) N.
Conotomaria gigantea (J. de C. Sowerby) D, B.
— *seendensis* Cox N.
— *lamplughi* Cox T.
Cimolithium astierianum (d'Orbigny) m.
Semisolarium moniliferum (Michelin) m.
— *astierianum* (d'Orbigny) T, m.
Proconulus esqueriae (de Verneuil & de Loriol) f.
Metriomphalus mantelli (Leymerie) F.
Chilodonta (*Agathodonta*) *dentigera* (d'Orbigny) M.
Eucycloscala mulleti (d'Archiac) T.
Tectus cf. *huoti* (d'Archiac) T.
'*Littorina*' *conica* (J. de C. Sowerby) N.
Eucyclus upwarensis (Keeping) N.
— sp. nov. cf. *albo-aptiensis* (Sinzow) m.
Ooliticia cantabrigensis (Keeping) N.
— *varicosa* (Keeping) N.
— *sp. nov.* f.
Ataphrus albensis (d'Orbigny) F, f, D.
Delphinula cf. *mailleana* (d'Orbigny) F.
Nododelphinula reedi (Keeping) N.
Fossarus munitus (Forbes) F, f.
'*Solarium*' *minimum* Forbes F, f, D.
Margarites (*Atira*) *mirabilis* Casey J, T.
— (—) *sp.* D, N.

Class SCAPHOPODA

Dentalium cylindricum J. Sowerby f, B, N.
— *jeffreysi* Gardner f.
— (*Fissidentalium*) *decussatum* J. Sowerby J-m.

Class CEPHALOPODA

Pictetia depressa (Pictet & Campiche) T.
Eogaudryceras shimizui Breistroffer T.
Ancyloceras mantelli Casey f.
— cf. *varians* d'Orbigny ?F
Tropaeum bowerbanki J. de C. Sowerby B.
— — var. *densistriatum* Casey B.
— *hillsi* (J. de C. Sowerby) D.
— *drewi* Casey B.
— *benstedi* Casey M.
— *subarcticum* Casey N.
Tropaeum keepingi Casey ?D.
— cf. *rossicum* Casey M.
Australiceras gigas (J. de C. Sowerby) D, B.
— *sp. nov.* D.
— *sp.* M.
Ammonitoceras tovilense Crick M.
— *spp. nov.* M.
Epancyloceras hythense Spath D.
— *sp. nov.* D.
Lithancylus grandis (J. de C. Sowerby) D.
— *sp. nov.* D.
Toxoceratoides royerianus (d'Orbigny) D.
— *proteus* (Spath) D.
— cf. *fustiformis* (v. Koenen) D.
— cf. *biplex* (v. Koenen) f.
Tonohamites decurrens Spath D, B.
— *aequicingulatus* (v. Koenen) B.
— *spp. nov.* B.
Hamites praegibbosus Spath m.
— *spp. nov.* m.
Protanisoceras raulinianum (d'Orbigny) m.
— *lardyi* (Pictet & Renevier) m.
— *cantianum* Spath m.
— *blancheti* (Pictet & Campiche) m.
— *acteon* (d'Orbigny) m.

Protanisoceras vaucherianum (Pictet) m.
— cf. *halleri* (Pictet & Campiche) m.
— *spp. nov.* m.
'*Prohelicoceras*' *anglicum* Spath m.
Gen. nov. ('*Protanisoceras*') sp. nov. m.
Aconeceras nisoides (Sarasin) F, f, ?D, B.
— cf. *nisum* (d'Orbigny) M.
— cf. *haugi* (Sarasin) f.
— *sp. nov.* T.
Sanmartinoceras (*Sinzovia*) *aptianum* (Sarasin) f.
— ? (— ?) *sp. nov.* T.
— (*Theganeceras*) cf. *falcatum* (v. Koenen) ?F.
Gen. nov. ('*Aconeceras*') sp. nov. M.
Beudanticeras newtoni nom. nov. (= *B. ligatum* Newton & Jukes-Browne sp., Spath) m.
— *arduennense* Breistroffer m.
— *dupinianum* (d'Orbigny) m.
— *laevigatum* (J. de C. Sowerby) m.
Uhligella subornata Casey m.
Pseudosaynella cf. *fimbriata* Imlay f.
— aff. *undulata* (Sarasin) f.
Roloboceras hambrovi (Forbes) f.
— *horridum* (Spath) f.
— *perli* (Spath) f.
— *spp. nov.* f.
Megatyloceras sp. nov. f.
Cheloniceras (*Cheloniceras*) *parinodum* sp. nov. D.
— (—) *cornuelianum* (d'Orbigny) D, B.
— (—) *kiliani* (v. Koenen) B.
— (—) *crassum* Spath D, B.
— (—) *meyendorffi* (d'Orbigny) B.
— (—) cf. *gottschei* (Kilian) B.
— (—) *spp. nov.* D, B.
— (*Epicheloniceras*) *tschernyschewi* (Sinzow) M.
— (—) *martinioides* sp. nov. M.
— (—) *debile* sp. nov. M.
— (—) *gracile* sp. nov. M.
— (—) *buxtorfi* (Jacob) M.
— (—) aff. *volgense* (Vasilievsky) M.
— (—) *spp. nov.* M.
Gen. nov. ('*Cheloniceras*') *sp. nov.* M.
Douvilleiceras mammillatum (Schlotheim) m.
— *monile* (J. Sowerby) m.
— *orbignyi* Hyatt m.
— *spp. nov.* m.
Deshayesites deshayesi (d'Orbigny) D.
— *consobrinoides* (Sinzow) D.
— *multicostatus* Swinnerton D.
— *grandis* Spath D.
— *vectensis* Spath D.
— *involutus* Spath D.
— *kiliani* Spath f.
— *topleyi* Spath f.
— *punfieldensis* Spath f.
Deshayesites forbesi sp. nov. f.
— *fittoni* sp. nov. f.
— *callidiscus* sp. nov. f.
— *spp. nov.* F, f, D.
Prodeshayesites obsoletus gen. et sp. nov. F.
— *fissicostatus* (Phillips) F.
— *bodei* (v. Koenen) F.
— *laeviusculus* (v. Koenen) F.
— *spp. nov.* F, f.
Dufrenoyia furcata (J. de C. Sowerby) B.
— *lurensis* (Kilian) B.
— *truncata* Spath B.
— *transitoria* sp. nov. B.
— *spp. nov.* B.
Parahoplites nutfieldensis (J. Sowerby) N.
— *maximus* Sinzow N.
— *cunningtoni* sp. nov. N.
— *spp. nov.* N.
Colombiceras sp. nov. cf. *tobleri* (Jacob) ?N.
Nolaniceras aff. *nolani* (Seunes) J.
Hypacanthoplites jacobi (Collet) J.
— *anglicus* Casey J.
— — var. *audax* Casey J.
— *simmsi* (Forbes) J.
— *rubricosus* Casey J.
— — var. *tenuiformis* Casey J.
— — var. *papillosus* Casey J.
— *elegans* (Fritel) J.
— cf. *hanovrensis* (Collet) J.
— *clavatus* (Fritel) J.
— cf. *sarasini* (Collet) J.
— cf. *laticostatus* (Sinzow) J.
— cf. *spathi* (Dutertre) J.
— *trivialis* Breistroffer T.
— *milletioides* sp. nov. T.
— cf. *milletianus* (d'Orbigny) m.
— *spp. nov.* J, T.
Parengonoceras ebrayi (de Loriol) m.
Farnhamia farnhamensis Casey T.
— *spp. nov.* T.
Tetrahoplites cf. *subquadratus* (Sinzow) m.
Sonneratia dutempleana (d'Orbigny) m.
— *kitchini* Spath m.
— *parenti* Jacob m.
— *perinflata* Breistroffer m.
— *spp. nov.* m.
Pseudosonneratia spp. nov. m.
Protohoplites (*Protohoplites*) *archiacianus* (d'Orbigny) m.
— (—) *latisulcatus* (Sinzow) m.
— (—) *michelinianus* (d'Orbigny) m.
— (—) *sp. nov.* m.
— (*Hemisonneratia*) *puzosianus* (d'Orbigny) m.
— (—) *gallicus* (Breistroffer) m.
— (—) *sp. nov.* m.

Otohoplites raulinianus (d'Orbigny) m.
— *elegans* (Spath) m.
— *guersanti* (d'Orbigny) m.
— *auritiformis* (Spath) m.
— *spp. nov.* m.
Anahoplitoides cf. *gigas* (Sinzow) m.
Anadesmoceras strangulatum Casey T.
— *subbaylei* (Spath) T.
— *baylei* (Jacob) m.
— *spp. nov.* T.
Cleoniceras (*Cleoniceras*) *cleon* (d'Orbigny) m.
— (—) *seunesi* Bonarelli m.
— (—) *quercifolium* (d'Orbigny) m.
— (—) *janneli* (Parent) m.
— (—) *morgani* Spath m.
— (—) *floridum* sp. nov. m.
— (—) *spp. nov.* T, m.
— (*Neosaynella*) *inornatum* Casey m.
— (—) *sp. nov.* m.
Leymeriella (*Leymeriella*) *tardefurcata* (d'Orbigny) T.
— (—) — var. *intermedia* Spath T.
— (—) — var. *densicostata* Spath T.
— (—) *regularis* (Bruguière) d'Orbigny sp. T.
— (—) *consueta* Casey T.
— (—) — var. *magna* Casey T.
— (—) *pseudoregularis* Seitz T.
— (—) *diabolus* Casey T.
— (—) *rudis* Casey T.
— (—) *renascens* Seitz T.
— (—) cf. *revili* (Jacob) T.
— (*Epileymeriella*) cf. *hitzeli* (Jacob) T.
Tegoceras gladiator (Bayle) m.
— *mosense* (d'Orbigny) m.
— *sp. nov.* m.
Oxytropidoceras alticarinatum (Spath) m.
Cymatoceras radiatum (J. Sowerby) F, D-J.
— *pseudoelegans* (d'Orbigny) F, D-N.
— *albense* (d'Orbigny) m.
Eucymatoceras plicatum (J. de C. Sowerby) F, D, B.
Eutrephoceras sublaevigatum (d'Orbigny) N.
— *clementinum* (d'Orbigny) m.
— *sp. nov.?* J, T.
Anglonautilus undulatus (J. Sowerby) (= *Nautilus farringdonensis* Sharpe) N.
Heminautilus saxbyi (Morris) f.
Conoteuthis dupiniana (d'Orbigny) f.
— *vectensis* Spath f.
Neohibolites ewaldi (v. Strombeck) D-N.
— *minimus* (Miller) T, m.
— *strombecki* (Müller) ?N.
— *spicatus* Swinnerton ?N.
— *wollemanni* Stolley ?N.
— *sp.* J.
Hibolites minutus Swinnerton ?F.
Oxyteuthis depressus Stolley ?F.

Phylum ARTHROPODA

Class CRUSTACEA

Sub-class MALACOSTRACA

Notopocorystes stokesi (Mantell) m.
Eucorystes broderipi (Mantell) m.
Goniodromites scarabaeus Wright & Wright T.
Goniodromites? M.
Plagiophthalmus nitonensis Wright & Wright m.
Cyphonotus incertus Bell T.
Diaulax carteriana Bell T.
Mithracites vectensis Gould F, f.
Homolopsis edwardsi Bell m.
Gen. nov. ('*Homolopsis*') cf. *depressa* Carter f, D.
Vectis wrighti Withers f.
Oriothopsis cf. *bonneyi* Carter J.
Meyeria magna M'Coy f.
Glyphea vectensis Woods F.
Homarus longimanus G. B. Sowerby F-m.
Enoploclytia tuberculata (Bell) T.
Linuparus carteri (Reed) f.

Sub-class CIRRIPEDIA

Cretiscalpellum unguis (J. de C. Sowerby) T, m.
— *aptiense* Withers N.
— *sp. nov.* f.
Pycnolepas rigida (J. de C. Sowerby) T.
Scalpellum (*Arcoscalpellum*) *simplex* Darwin M.
— (—) *accumulatum* Withers N, T.
— (—) *comptum* Withers f, B.
Virgiscalpellum wrighti Withers f.

VERTEBRATA

Phylum PISCES

Hybodus complanatus Owen B.
— *basanus* Woodward F.
— *obtusus* Agassiz N.
— *subcarinatus* Agassiz F.
Acrodus ornatus Woodward F, f.
— *laevis* Woodward m.
Synechodus tenuis Woodward B.
Heterodontus sulcatus Woodward B.
Sphaerodus neocomiensis Agassiz N.
Gyrodus atherfieldensis White f.
Mesodon couloni (Agassiz) N, m.
Scapanorhynchus subulatus Agassiz T.
— *raphiodon* Agassiz? T.
— *sp.* F, f.
Apateodus sp.? T.
Lamna appendiculata Agassiz T, m.
Isurus mantelli (Agassiz) J-m.

Unidentified elasmobranch teeth and vertebrae F-m.
Ischyodus thurmanni Pictet & Campiche M.
Edaphodon sp. J.
Hylaeobatis problematica Woodward F.

Phylum REPTILIA

Pelorosaurus (= *Dinodocus*) *mackesoni* (Owen) B.
Iguanodon mantelli Meyer B, N.
Camptosaurus sp. m.
Acanthopholis horridus Huxley m.
Ichthyosaurus campylodon Carter J, m.
Polyptychodon interruptus Owen m.
Polyptychodon continuus Owen B.
Cimoliosaurus latispinus (Owen) B.
— *planus* (Owen) ?F.
Cimoliosaurus bernardi (Owen) ?F.
Pliosaurus sp. B.
Protemys serrata Owen D.
Unidentified thalassemyd turtle f.

PROBLEMATICA

Hallimondia fasciculata gen. et sp. nov. N.
Petromonile benstedii (Bensted) M.
Granularia spp. f, J. T.
Chondrites targionii (Brongniart) D-N.
— *spp.* F-m.

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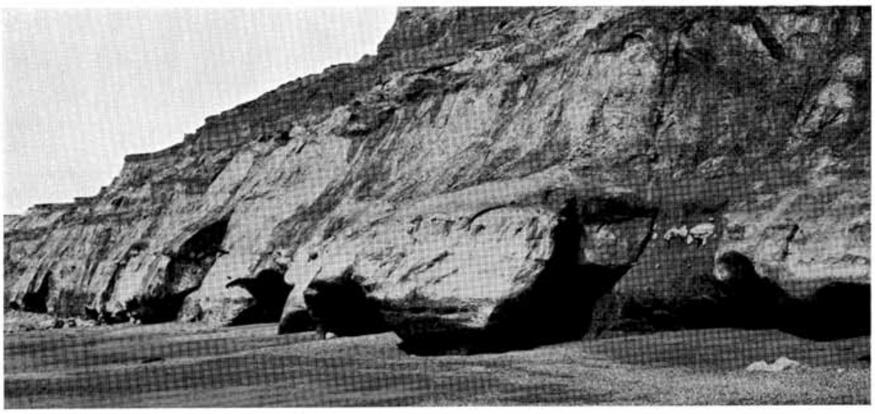
Note added in proof. Recent collecting has produced the following important addition to the list of Lower Greensand ammonites on pages 608–10: *Cymahoplites sp. nov.*, Folkestone Beds, main *mammillatum* bed, Copt Point, Folkestone (GSM 99240; author's coll.). This is a boreal genus of ammonites otherwise known only by its type species, *C. kerenskianus* (Bogoslowsky), from the Albian of Central Russia.

1



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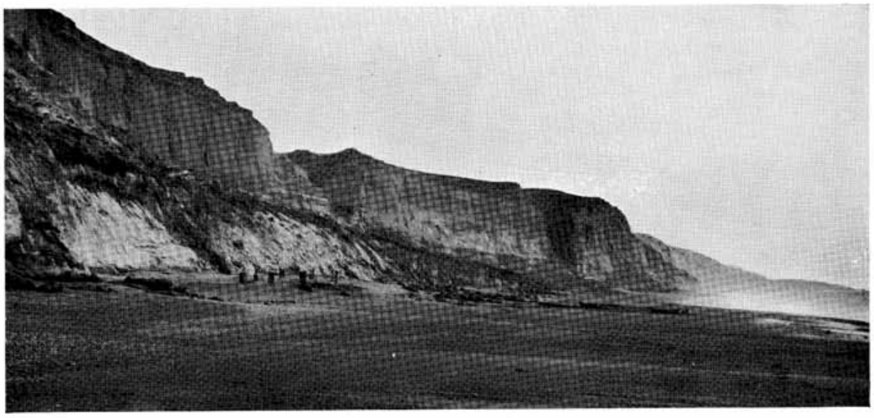


3

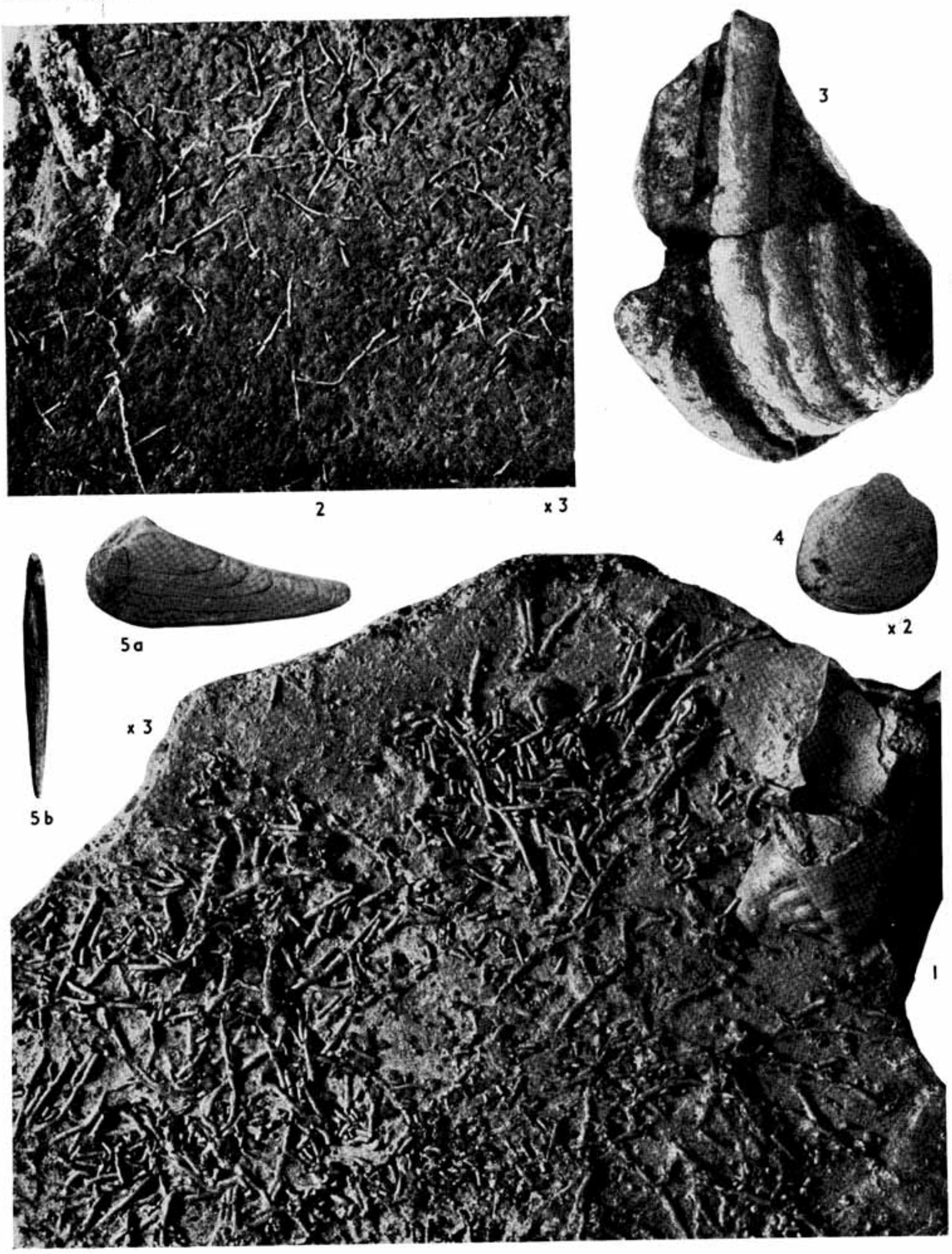
CASEY, *Lower Greensand, Isle of Wight*

1

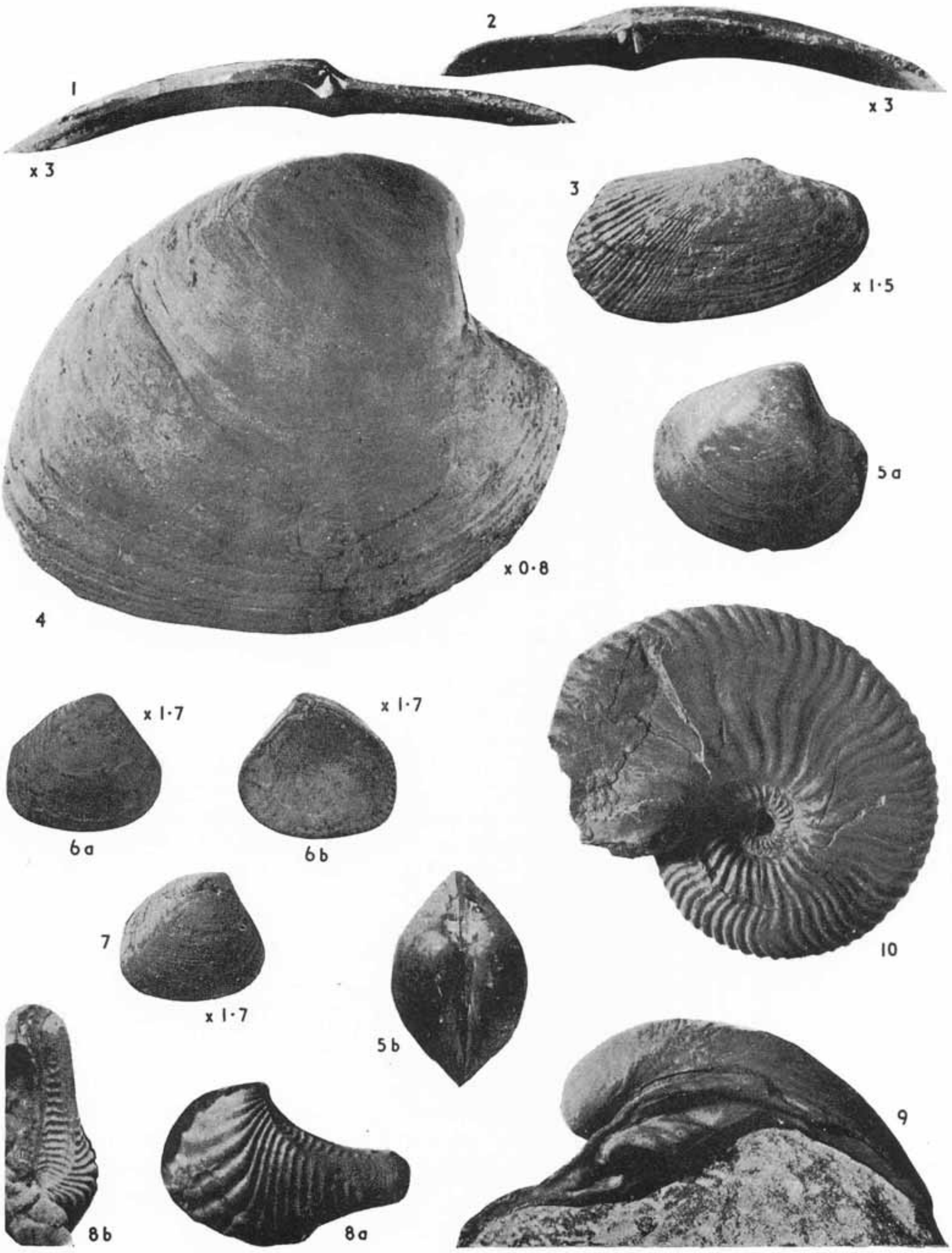
2

3

CASEY, *Lower Greensand and Gault, East Kent*



CASEY, *Lower Greensand fossils*



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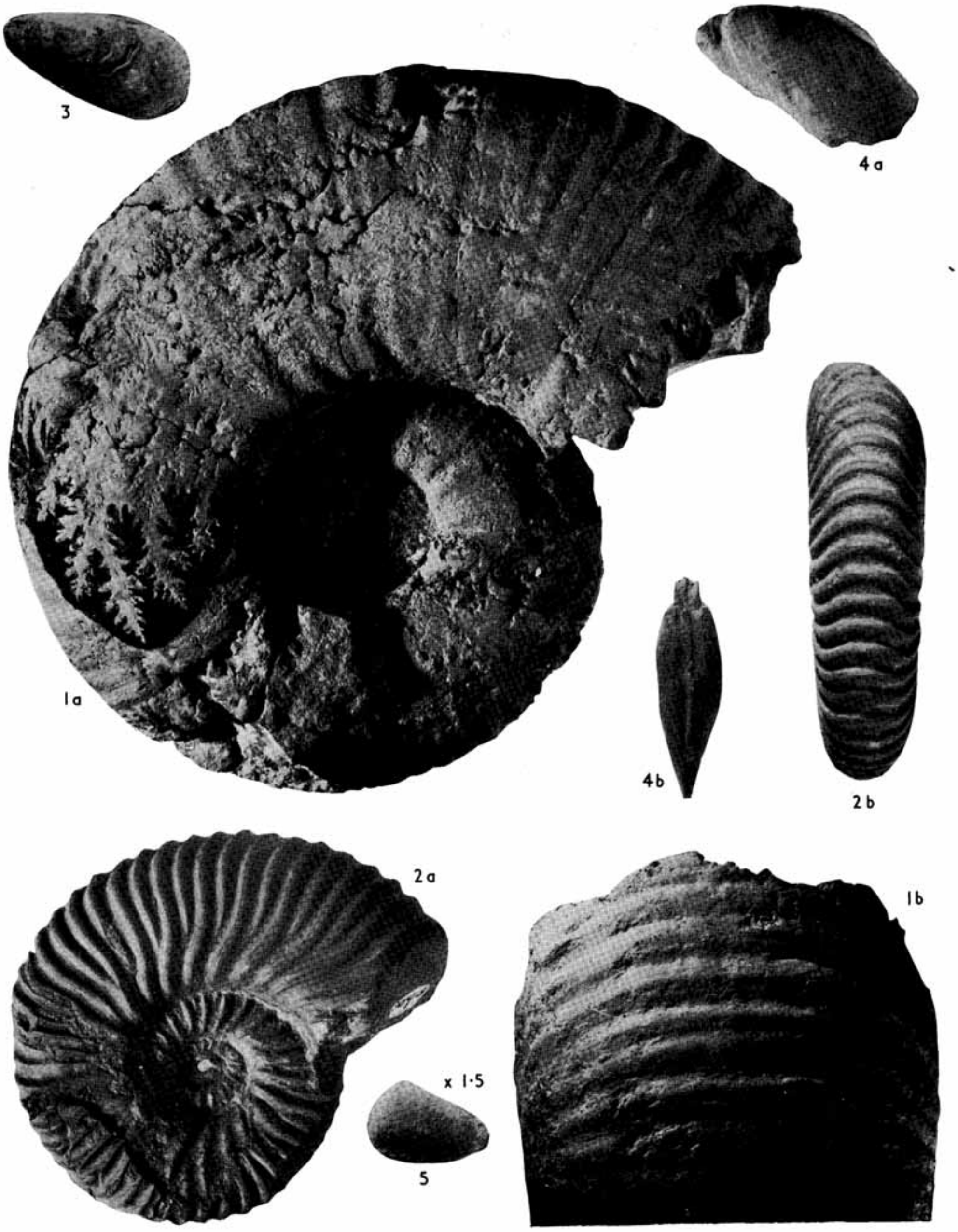

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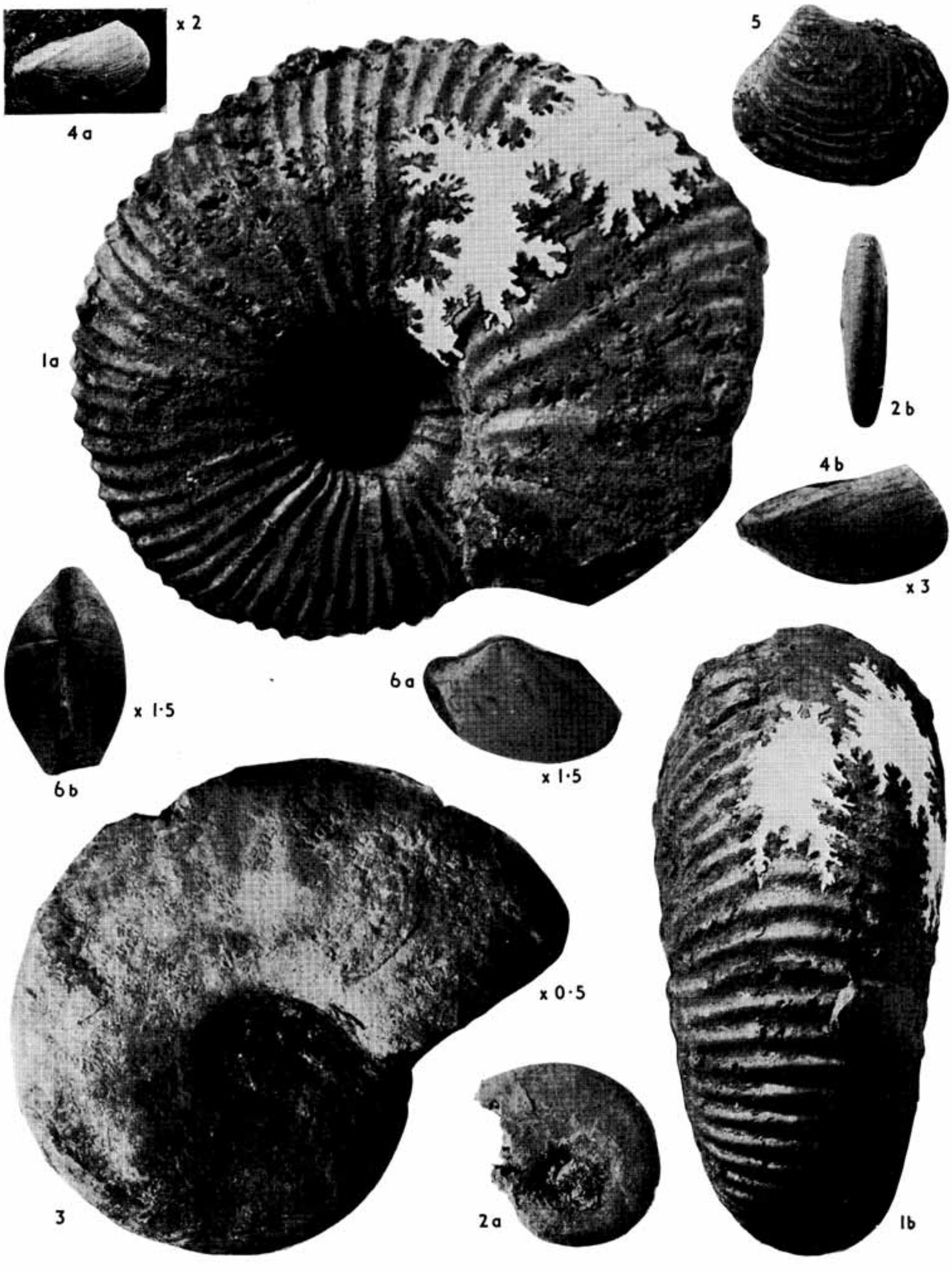

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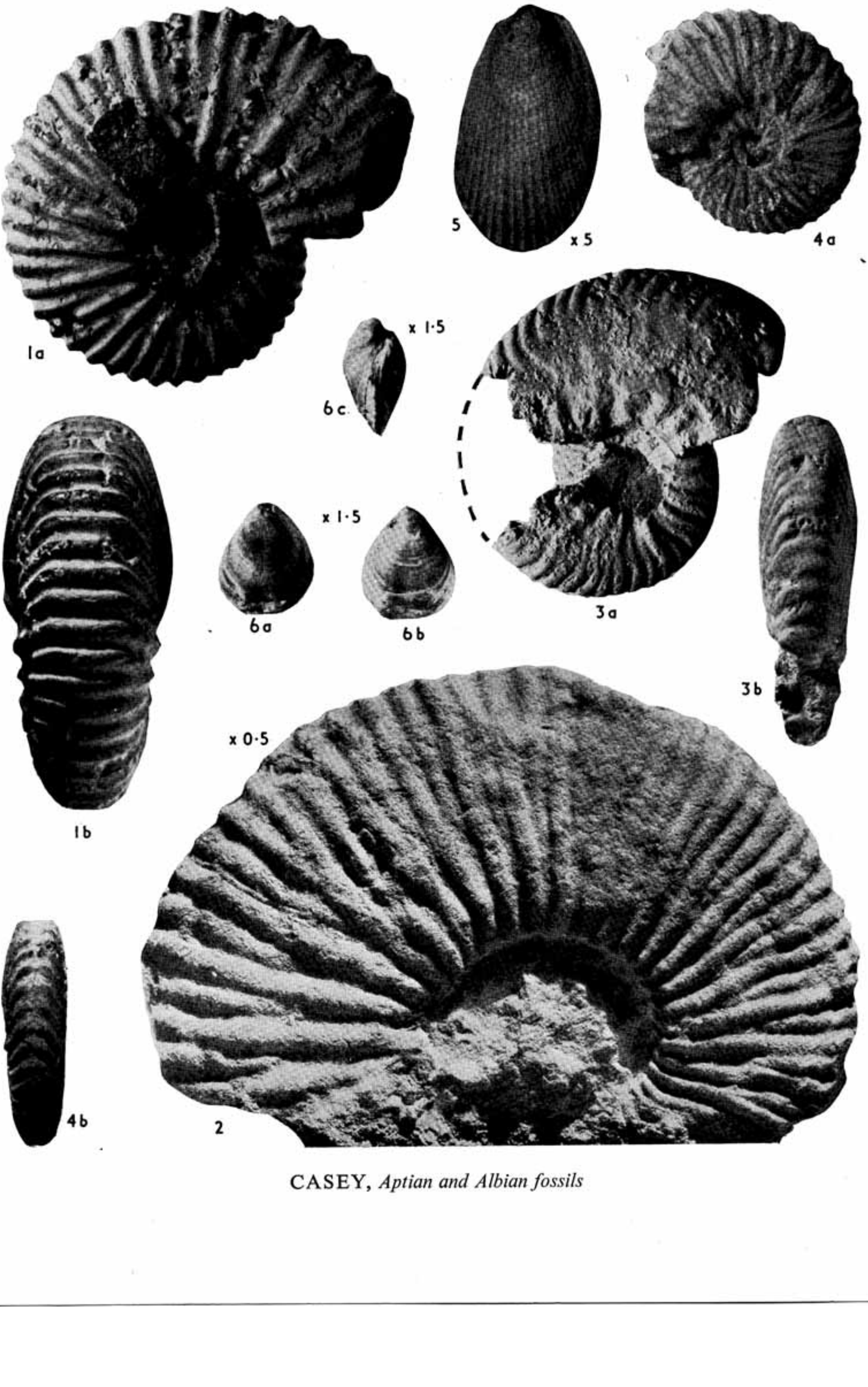
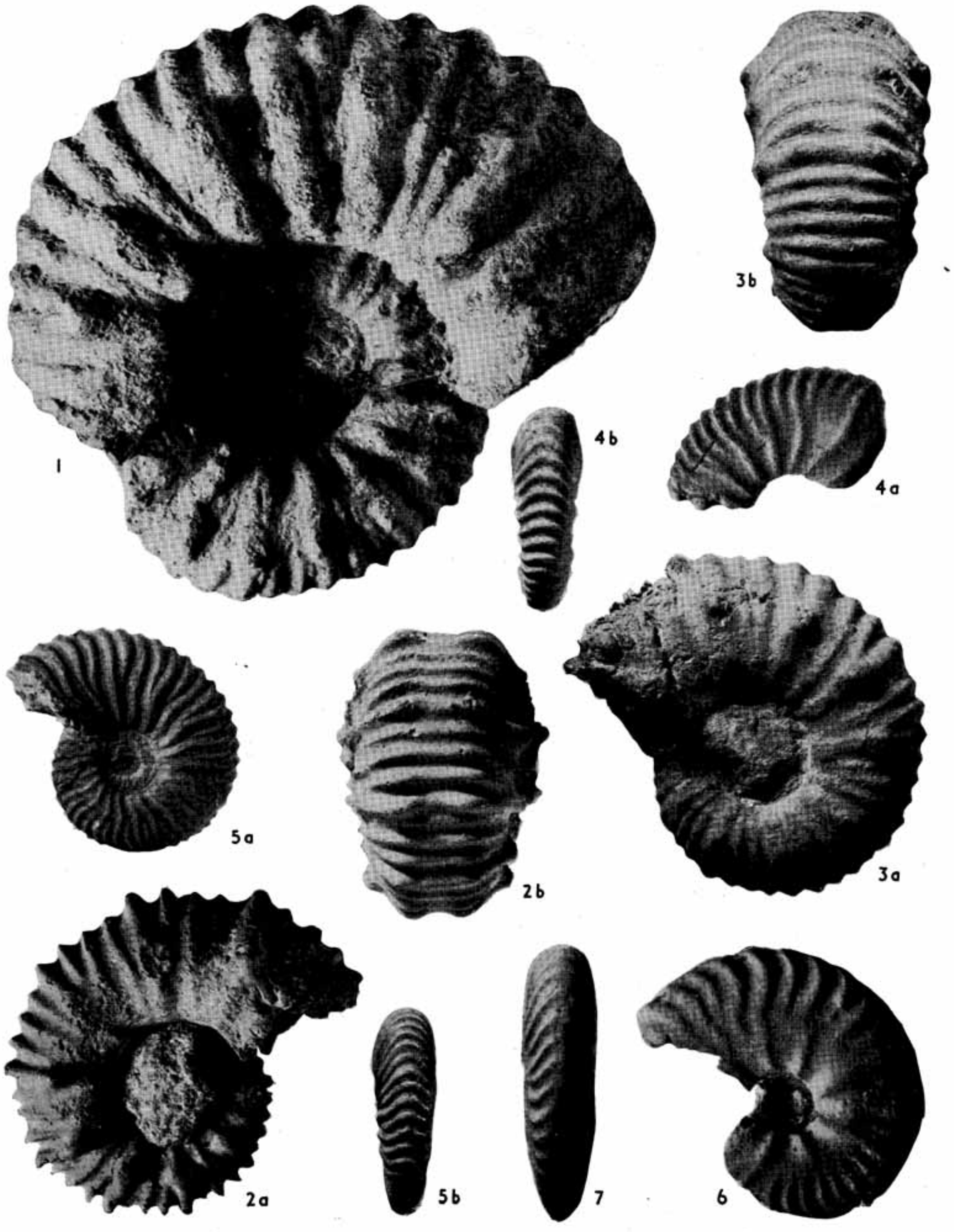


CASEY, *Aptian and Albian fossils*



CASEY, *Lower Greensand ammonites*