

ABSTRACT

The question of the exact age of the late-Palaeogene sediments of the Isle of Wight has long been a subject of controversy. Although the age of the uppermost beds of this system - the Hamstead Corbula beds - is generally accepted to be Oligocene, there is no unanimous opinion regarding the age of the underlying Headon and Bembridge series. A study of the Foraminifera from the marine beds was undertaken to clarify the disputed problem of the age of these sediments.

Over 100 samples from five different sections of the marine beds of the Headon, Bembridge and Hamstead series were collected. These have yielded a foraminiferal fauna of 65 species and varieties, belonging to 31 genera of 12 families; these include 3 new species and 3 new varieties. All the forms are described and illustrated.

The foraminiferal assemblages of the Middle Headon Beds appear to indicate a marine environment in the east (Whitecliff Bay area), and an offshore, brackish to marine environment in the west (Headon Hill and Colwell Bay area). The assemblage of the Bembridge Oyster beds also points to an environment similar to that in the latter area. The fauna of the Hamstead Corbula beds, however, indicates a uniform marine environment, though somewhat brackish conditions prevailed at first.

In view of the limited number of species found in these beds, no exact correlation could be made with equivalent horizons in Europe. However, the known stratigraphic ranges of the species confirms the view that the Hamstead Corbula beds should be assigned to the Middle Oligocene. On the other hand, a somewhat transitional foraminiferal fauna, containing both Eocene and Oligocene species, occurs in the Middle Headon beds and also in the Bembridge Oyster beds. There is limited evidence to suggest that these beds are probably of Lower Oligocene age.

A STUDY OF THE FORAMINIFERA
OF THE
LATE PALAEOGENE SEDIMENTS
OF THE
ISLE OF WIGHT.

By

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I.

INTRODUCTION.

Numerous authors have studied the 'Fluvio-Marine' formation of the Isle of Wight since the pioneer work of Thomas Webster in 1816. Several stratigraphical classifications have been proposed, and the beds have been correlated with various members of the European Tertiaries. Most authors favour a correlation with the European Oligocene, though unanimous agreement has by no means been reached.

The lack of unanimity in the writings of earlier workers is due more to the circumstances of deposition of the beds concerned, than to lack of knowledge of the contained faunas. For example, the lowermost marine beds of this series do not rest directly on marine Eocene, but on the freshwater Lower Headon beds, the exact age of which is controversial. Again, whereas the British beds are dominantly non-marine, those of Belgium, Northern Germany and to some extent those of France, are largely marine. Unfortunately, studies of the contained faunas of the deposits in the Isle of Wight have not provided a decisive answer concerning their age. When dealing with beds of this type in which rapid facies variations are liable to occur both laterally and vertically, difficulty is always experienced in selecting the faunules (an assemblage of fossils) (Fenton & Fenton, 1928) valid for use in correlations. Many of these faunules, which in the past

have been thought to contain significant species, must be rejected on the grounds that they are merely expressions of a peculiar set of ecological conditions which may occur or even recur at different places. Furthermore, the evidence provided by the terrestrial vertebrate faunas and the marine faunas is to some extent contradictory. It is difficult to say whether these anomalies result from an incomplete knowledge of the time ranges of the species concerned, or from differential speeds of migration of the various species in the two faunas. In view of these difficulties, it is hardly surprising that there is no unanimous opinion concerning the age of these beds.

In recent years it has been found by various authors that detailed studies of foraminiferal assemblages provide much useful information regarding both the conditions of deposition and the age of the enclosing sediments. In view of the success achieved by these studies in the solution of problems of correlation and the interpretation of palaeoecology, a study of the Foraminifera of the late Palaeogene sediments of the Isle of Wight was undertaken, and the results of these researches form the basis of the present thesis.

II. THE LATE PALAEOGENE SEDIMENTS OF THE ISLE OF WIGHT.

For over a century the late Palaeogene sediments or 'Fluvio-Marine' formation of the Isle of Wight have excited the curiosity of geologists and have been a subject of controversy in the Tertiary geology of the British Isles.

The first scientific description of these beds was by Thomas Webster (Englefield, 1816). The Headon Hill section was designated the type locality, and the deposits were compared with the freshwater beds of the Paris Basin. On the basis of this comparison the 'Fluvio-Marine' deposits were subdivided into an "Upper Freshwater, an Upper Marine and a Lower Freshwater formation". Webster's pioneer work on these deposits opened the way to more detailed and comprehensive research, not only from the point of view of palaeontology and stratigraphy, but also in numerous other fields of investigation to be developed in the later part of the 19th and in the 20th century.

In 1853, Edward Forbes completed his work on the 'Fluvio-Marine' tertiaries of the Isle of Wight. His subdivisions of these beds is eminently satisfactory, and has since been adopted in its entirety by a large majority of later authors.

Stratigraphy and General Distribution.

The Oligocene or late Palaeogene sediments occupy the entire northern half of the island and are well exposed

in the sections at Whitecliff Bay, Headon Hill, Totland and Colwell Bays, and at Hamstead and Bouldnor cliffs. They consist of a varied set of clays, marls, sands and limestones of mixed freshwater, estuarine and marine origin. They have been separated into four divisions, which are, in descending order:-

- d. Hamstead Beds.
- c. Bembridge Beds.
- b. Osborne Beds, and
- a. Headon Beds.

(a) Headon Beds.

The Headon beds were first described from the coastal cliff section below Headon Hill on the west coast, where they are about 147 ft. thick. From Headon Hill the beds can be traced along the coast through the sections exposed at Totland and Colwell Bays as far north as Cliffend. On the east coast, however, a much better and typical section is observed at Whitecliff Bay, with a total thickness of about 212 ft. On the mainland the Headon beds are exposed at Hordwell cliff (the Lower Headon beds⁺ only) and near Brockenhurst in the New Forest area (mainly the Middle Headon marine or 'Brockenhurst beds'), but these beds are not so well exposed.

The Headon series has been subdivided into three stages:-

- (iii) Upper Headon (Fresh-and Brackish-water),
- (ii) Middle Headon (Marine and Brackish-water),
- (i) Lower Headon (Fresh-and Brackish-water).

(i) Lower Headon Beds:- Resting on the Barton sands are the Lower Headon beds, about 61 ft. thick in the type section at Headon Hill and consisting of fresh- and brackish-water sediments. Lithologically they are essentially clays and limestones with occasional bands of lignite and ferruginous material. The limestone forming the uppermost bed of this series is a very distinctive deposit. It varies in thickness from 3 to 6 ft. and can be traced throughout the west coast sections. Near Colwell chine, the same limestone band is exposed on the shore at low tide and is called the 'How ledge' Limestone.

The most conspicuous fossils of these limestone bands are Limnaea longiscata Brongniart, Planorbis euomphalus J.Sowerby, Viviparus lentus (Solander), and Stenothyra parvula (Morris). Other not so common forms are Erodona and Cyrena. The only plant remains are the fruits of Chara sp.

These prominent limestone bands of the west coast section are absent in the east coast section at Whitecliff Bay, where the lower Headon beds are represented solely by marls and clays, and the total thickness is reduced to about 28 feet.

(ii) Middle Headon Beds. (Upper Marine formation of Webster).

The Middle Headon beds represent the marine and brackish-water stages of the Headon series and are well exposed at Headon Hill (33 feet), Totland and Colwell Bays (about 28 - 30 feet), Whitecliff Bay (26 feet), and on the mainland near Brockenhurst in the New Forest area (where the exact thickness is not known). These beds have also been proved at a number of places by boreholes e.g. near Freshwater, Newport, West Cowes, etc.

The Middle Headon beds of the Whitecliff Bay are more typically marine than on the west coast of the island, and contain additional beds (the 'Brockenhurst^{beds}') at the base, which probably thin out towards the west and are consequently unrepresented on the west coast. The Middle Headon beds in the west coast sections show an admixture of fresh-water and marine molluscs to a greater extent than at Whitecliff Bay in the east. It is therefore probable that the marine transgression which resulted in the deposition of these beds came from the east or northeast.

The most typically marine fossil in the Middle Headon beds is Cordiopsis incrassata (J.Sowerby). This species was originally included in the genus Venus, and it was after this abundant fossil that the 'Venus Bed' was named. Other abundant forms are Nucula headonensis (Forbes), Batillaria concava (J.Sowerby), Melanopsis fusiformis

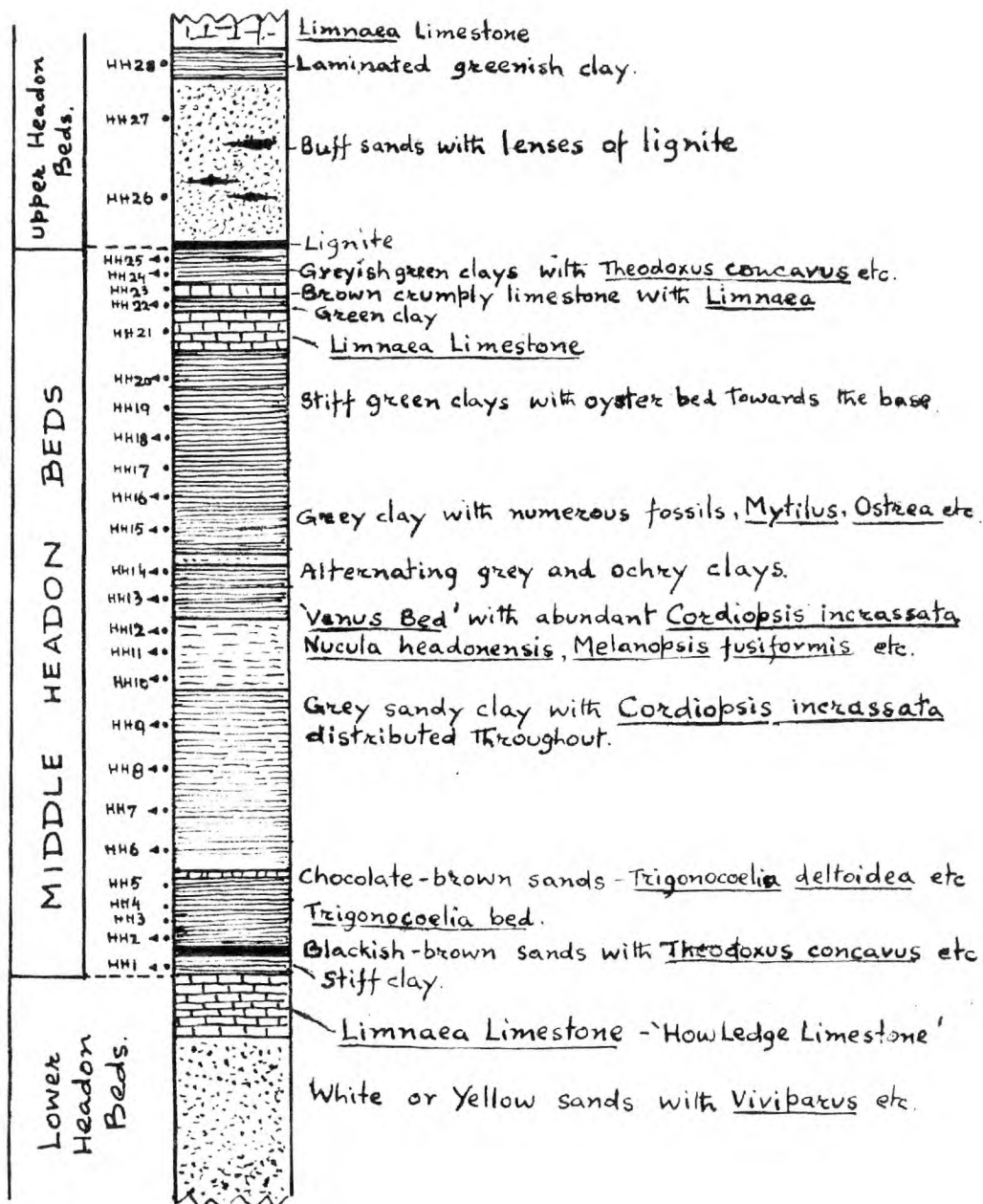
VERTICAL SECTION OF THE MIDDLE HEADON BEDS AT NORTH-EAST CORNER OF HEADON HILL.

(After Keeping & Tawney, G. J. G. S., vol. 37, 1881, p. 91)

Scale 8 ft = 1 inch.

LEGEND

- Sample Horizons.
- * Foraminifera present.



(J.Sowerby), Theodoxus concavus (J.Sowerby), Ancillaria buccinoides (Lamarck) and some species of Natica, Pleurotoma and Cancellaria. Voluta sp. and a few corals, e.g. Solenastraea sp. and Lobopsammia sp., are among some of the characteristic fossils of the Brockenhurst beds.

Description of the Middle Headon bed sections.

I. HEADON HILL:- The succession observed in the Middle Headon beds at the north-east corner of Headon Hill is generally similar to that described by Keeping and Tawney (1881, p.91) (see Plate I). The thicknesses given below (in parentheses) are approximate, as they vary considerably from place to place.

Resting on the Limnaea limestone of the Lower Headon beds are the lowermost beds of the Middle Headon, consisting of greyish-brown clay (1 feet 6 inches) and containing abundant specimens of Theodoxus concavus (J.Sowerby). The top 6 inches is more brownish in colour.

The overlying bed is composed of chocolate-coloured sands (3 feet) and is called the Trigonocoelia bed, after the common fossil T.deltoides (Lamarck).

Next above is the well known 'Venus Bed' (11 feet), consisting of grey sandy-clay and abundant specimens of Cordiopsis incrassata (J.Sowerby). Other abundant forms are Nucula headonensis (Forbes), Melanopsis fusiformis (J.Sowerby) and Ancillaria buccinoides (Lamarck).

The beds which follow above this are stiff green clays (11 feet). The characteristic fossils are Mytilus affinis (J.Sowerby) and Ostrea sp. The lower 3 feet of these are greyish-brown in colour.

The overlying beds forming the uppermost portion of the Middle Headon beds are a set of alternating freshwater limestones and brackish-water green clays. The two limestone bands are yellowish-brown in colour and of soft crumbly nature. Between these two bands is a 6 inch band of green clay. The uppermost bed of this series is thick greyish-green clay (2 feet), in which Theodoxus concavus (J.Sowerby) is abundant.

The succeeding bed is of freshwater origin and forms the lowermost bed of the Upper Headon series.

2. COLWELL BAY:- The section of the Middle Headon beds at Colwell Bay is very similar to the one at Headon Hill, with some minor differences owing to the lateral variation in the character of many beds and the thinning of others. The fossils found in the Middle Headon beds at Colwell Bay are much more abundant numerically than those found at Headon Hill, and probably slightly more marine in character, (indicated by the presence of large banks of oysters). The Colwell Bay beds are more easily accessible than those at Headon Hill and this may partly account for the apparently richer fauna at the former locality. It was perhaps owing to

VERTICAL SECTION OF THE MIDDLE HEADON BEDS

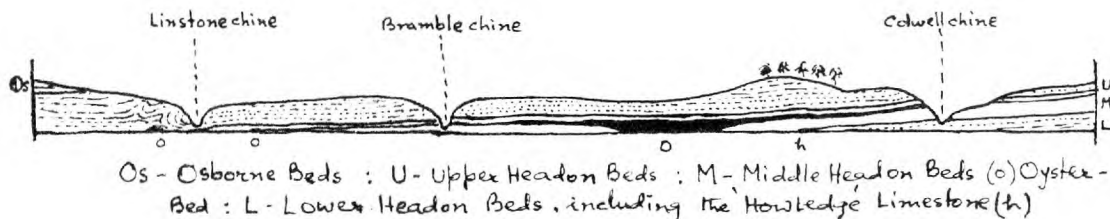
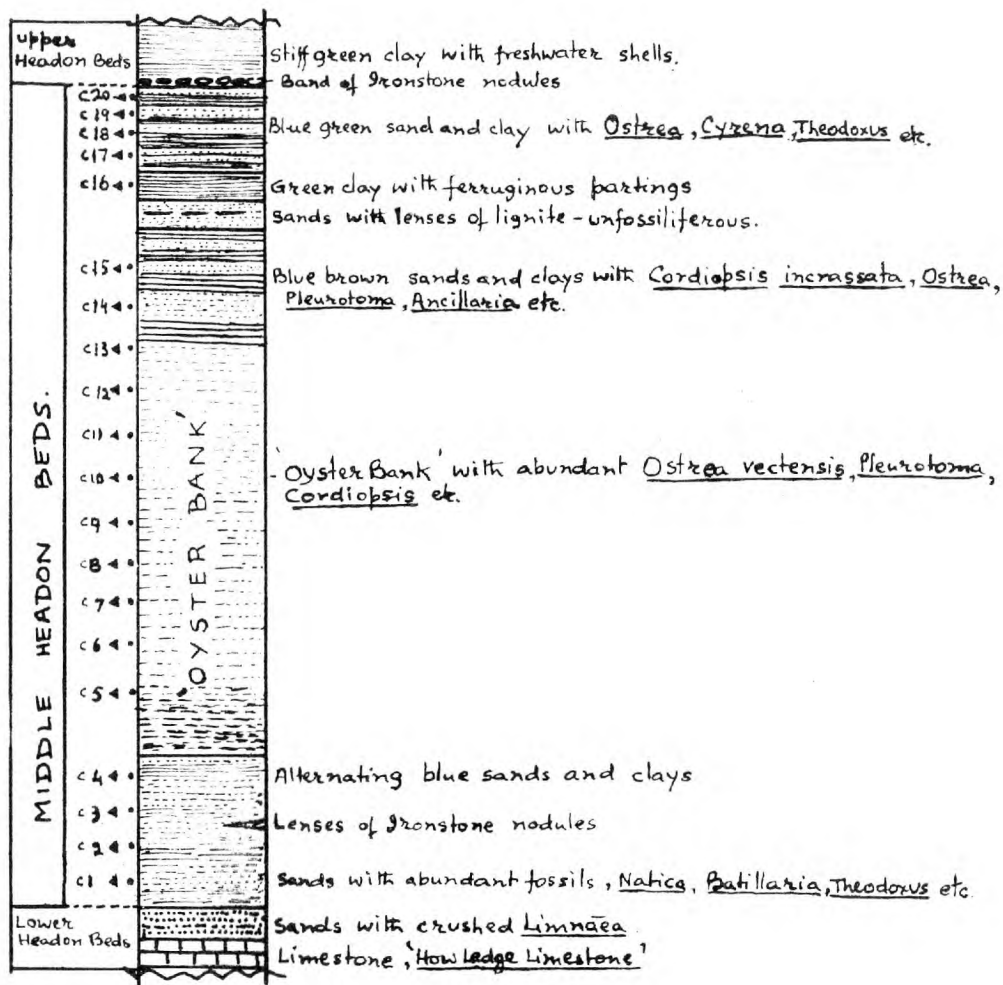
AT COLWELL BAY (about midway between Bramble and Colwell chines)

Legend

• Sample Horizons.

• Foraminifera present.

Scale 7ft = 1 inch.



Section in Colwell Bay

(After Osborne White, 1921, p. 117)

these factors that many authors (Hébert, 1852; Judd, 1880) were misled into regarding the Colwell Bay marine beds as later in age than those of Headon Hill. Keeping and Tawney (1881, p.108) state that - "There is but one marine bed here, namely that in the Middle Headon; for the Colwell-Bay bed can be traced stratigraphically (their italics) into the Headon Hill Venus-bed, and the palaeontological evidence is in harmony with the stratigraphical. The place of the Brockenhurst bed is at a lower horizon in the Middle Headon; but it does not appear anywhere in the west of the island."

The best exposed and most extensive section of the Middle Headon beds in Colwell Bay is seen at a point about midway between Colwell chine and Bramble chine (see Plates II and VIa). The lowermost bed is composed of greyish-blue sand in which Theodoxus concavus (J.Sowerby) is abundant. The overlying beds consist of laminated blue clays and sands with occasional lenticular ironstone partings. It is not possible to determine their exact thickness at this locality since they are very variable - both in lithology and thickness. The bed which follows next above is the 'Venus Bed', which contains abundant specimens of Cordiopsis incrassata (J.Sowerby). Other fossils are Ostrea velata Wood, Ancillaria sp., and Pleurotoma sp.

Within the 'Venus Bed' at this locality, specimens of Ostrea occur in abundance, forming an accumulation of shells about 18 - 20 feet thick. This 'Oyster Bank' thins

out on either side towards Bramble and Colwell chines. The oyster shells, which are usually found complete, and which appear to have been drifted into the 'Venus Bed', apparently accumulated in a hollow produced by local contemporaneous erosion during the deposition of the 'Venus Bed'.

The Oyster Bed is succeeded by a thin band composed of sands and lignites, devoid of fossils. These are probably equivalent to the freshwater limestones of the upper part of the Middle Headon beds at Headon Hill. They are overlain by 4 feet of bluish-green clays full of fossils (Ostrea, Cordiopsis, Theodoxus spp., etc.,) and with occasional ironstone partings. Separating these Middle marine beds from the overlying freshwater beds is a thin band of ironstone nodules which is particularly well developed near Bramble chine.

3. WHITECLIFF BAY:- The best developed section of the Middle Headon beds on the island occurs at Whitecliff Bay on the east coast (see Plates III and VIII), where they attain a thickness of 126 feet (White, 1921, p.119).

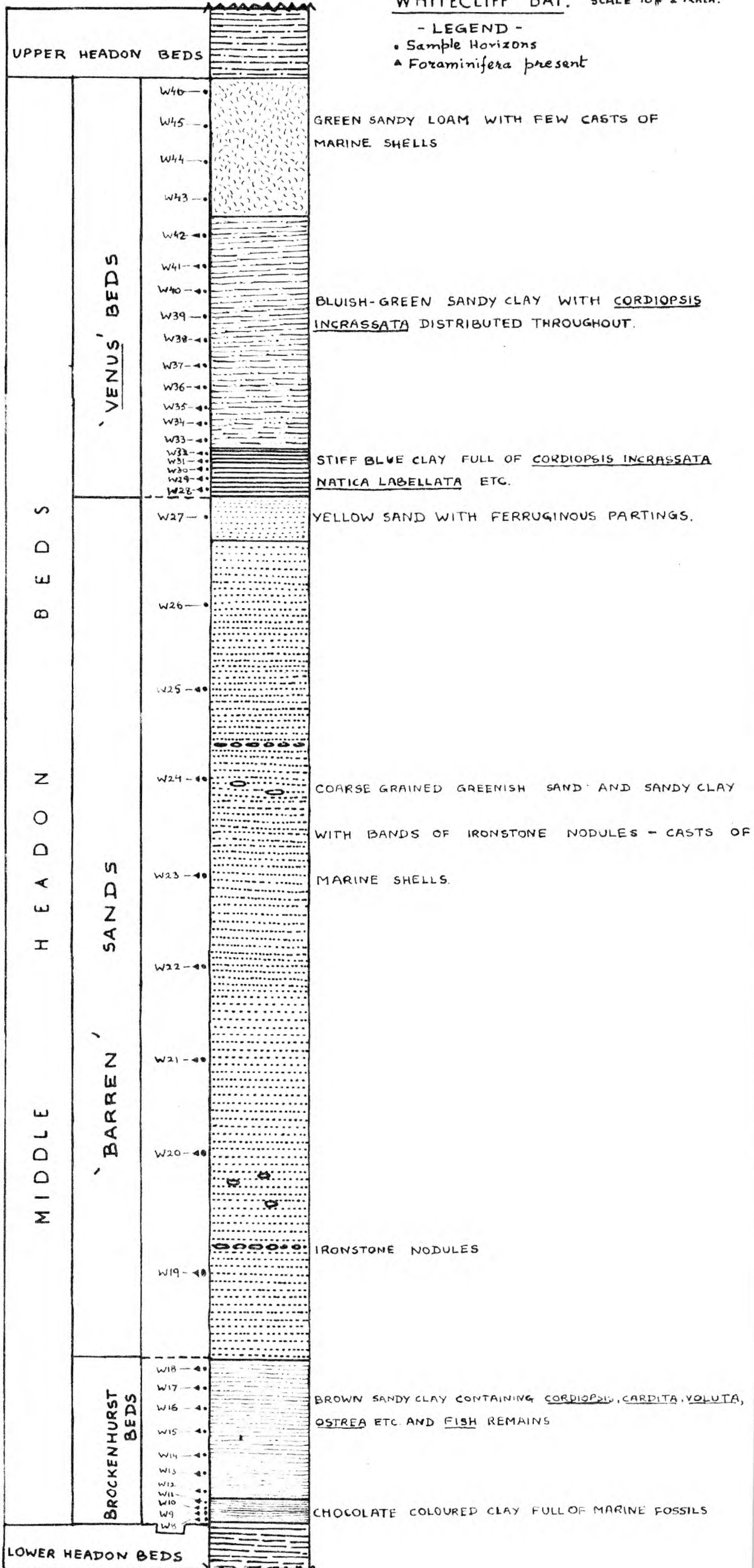
Overlying the Lower Headon freshwater series is the lowest bed of the Middle Headon marine series, which contains abundant marine mollusca, polyzoa and even some badly preserved corals. The change in fauna from freshwater to marine at the junction is not a gradual one as some authors have

VERTICAL SECTION OF THE MIDDLE HEADON BEDS AT

WHITECLIFF BAY. SCALE 10 ft = 1 inch.

- LEGEND -

- Sample Horizons
- ▲ Foraminifera present



implied, but sharp and sudden. This has been amply demonstrated by Keeping and Tawney (1881, p.109) who state that the marine series lies upon an eroded surface of the underlying freshwater Lower Headon beds.

The lowermost 14 feet of the Middle Headon beds at Whitecliff Bay are known as the Brockenhurst beds, which have been subdivided by Keeping and Tawney (op.cit., p.109) into a lower 'Brockenhurst zone' (2 feet) and an upper 'Roydon zone' (12 feet). The Brockenhurst beds are composed of brown to chocolate-coloured sandy clays and contain abundant specimens of Cordiopsis incrassata (J.Sowerby), Voluta geyminata (J.Sowerby), Ostrea sp. and Fusinus.sp. Modiola sp. and some badly preserved corals also occur. The outcrop of the Brockenhurst beds at Whitecliff Bay is seldom clearly exposed and is usually covered with extensive landslips. The clay mantle has to be removed before the underlying beds can be seen. The equivalence of these beds with the Brockenhurst beds of the New Forest area has been amply confirmed by the study of the fauna of these beds by Fisher (1862), von Koenen (1864), Duncan (1866), Codrington (1868), Judd (1880), and Keeping and Tawney (1881).

The overlying beds are composed of coarse-grained bluish-green sands with occasional bands of ironstone nodules. They may be called the 'Barren' sands - since they are for the most part unfossiliferous. However, some obscure casts of marine shells have been reported from these beds. The

uppermost 4 feet of the 'Barren' sands are composed of yellowish-white sands.

The beds which overlie the 'Barren' sands are usually grouped as 'Venus Beds', as they contain abundant specimens of Cordiopsis incrassata (J.Sowerby). The 'Venus-Beds' are divisible into a lower bed composed of stiff blue clay (4 ft.) and an upper of bluish-green sandy clay (12 feet). The uppermost bed of the Middle Headon beds at Whitecliff Bay consists of green sandy loam (about 12 feet) with a few doubtful casts of marine shells. It passes imperceptibly into the overlying freshwater Headon beds. The bed of green sandy loam may also be grouped with the 'Venus Beds'.

(iii) Upper Headon Beds:- The Upper Headon beds, like the freshwater Lower Headon beds, consist of limestones and variegated clays and sands. The limestones once again form prominent features on Headon Hill and are absent at Whitecliff Bay. The thickness varies from 47 feet (at Headon Hill) to 58 feet (at Whitecliff Bay). The fossils are generally similar to those found in the Lower Headon beds.

(b) OSBORNE BEDS.

The Osborne beds exhibit a more varied lithology than the Upper Headon beds and are entirely of freshwater origin. They consist of highly coloured red and green marls with occasional intercalated bands of limestones and sands.

The mollusca are similar to those found in the underlying freshwater Headon beds, but certain fish remains are characteristic, and Chara fruits are abundant. They attain a thickness of about 80 feet in the east and west coast sections, and 110 feet in the north near Cowes and Osborne (White, 1921, p.121). The Osborne beds are exposed at Headon Hill, Cliffend, Osborne, Binstead, Nettlestone point, St.Helens, Whitecliff Bay, and a number of other localities.

(c) BEMBRIDGE BEDS.

The Bembridge series may be divided into 3 stages :-

- (iii) Bembridge marls - Freshwater.
- (ii) Bembridge Oyster bed - Brackish-water & Marine.
- (i) Bembridge Limestone - Freshwater.

(i) The Bembridge Limestone:- Overlying the red and green marls and clays of the Osborne series is the Bembridge limestone (9 - 25 feet thick). The limestone is a very conspicuous feature of the 'Fluvio-Marine' formation and is readily distinguished by its creamy white colour and brecciated appearance. Freshwater molluscs such as Limnaea and Planorbis are usually found as casts. It also contains numerous mammalian remains. Towards the top it becomes more marly. The limestone is well developed at Binstead, Cowes, Sconce, and Whitecliff Bay.

(ii) The Bembridge Oyster bed:- Overlying the marls and limestone is the Bembridge Oyster bed, which has frequently

been confused with the Upper Marine series of Webster, although it lies much higher in the series. The Oyster bed is of great interest, since it evidently points to the return of marine conditions, as shown by the abundance of Ostrea vectensis Forbes, Cordiopsis incrassata (J.Sowerby), Arca websteri Forbes, and other marine molluscs.

Description of section at Whitecliff Bay:-

The Oyster beds are best developed at Whitecliff Bay - near Foreland Point - where the limestone outcrops just above sea level and forms the foreshore (see Plate VIII, Locality 4). The following section is observed (see Plate IVa):-

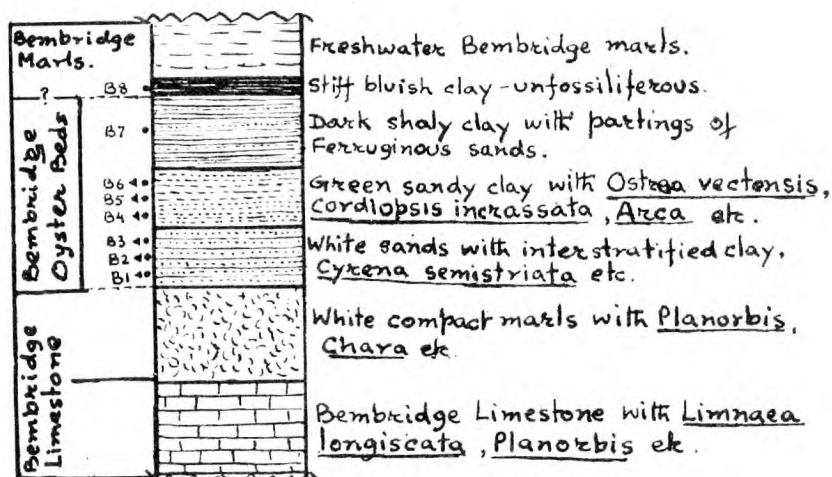
The Bembridge limestone is overlain by white compact marl, 3 feet thick, and abounding with freshwater molluscs. It is customary to group this marl with the limestone below. The marl is overlain by a 2 feet thick band of greenish-white sand with interstratified clay containing Cyrena semistriata Deshayes. Next above is a green sandy bed (2 feet), with abundant marine molluscs - Ostrea vectensis Forbes, Mytilus affinis J.Sowerby, Arca websteri Forbes, and Cordiopsis incrassata (J.Sowerby). Occasionally below this Oyster bed, a compact whitish marl 6" thick may be observed. It appears to be lenticular and impersistent. The bed which overlies the Oyster bed is a band of blue shaly clay (2 feet 6 inches), with partings of ferruginous sand. Fossils are sporadically distributed throughout. A 6" band of hard bluish un-

PLATE IV. (a) VERTICAL SECTION OF THE BEMBRIDGE OYSTER BEDS
NEAR BEMBRIDGE LEDGE, WHITECLIFF BAY.

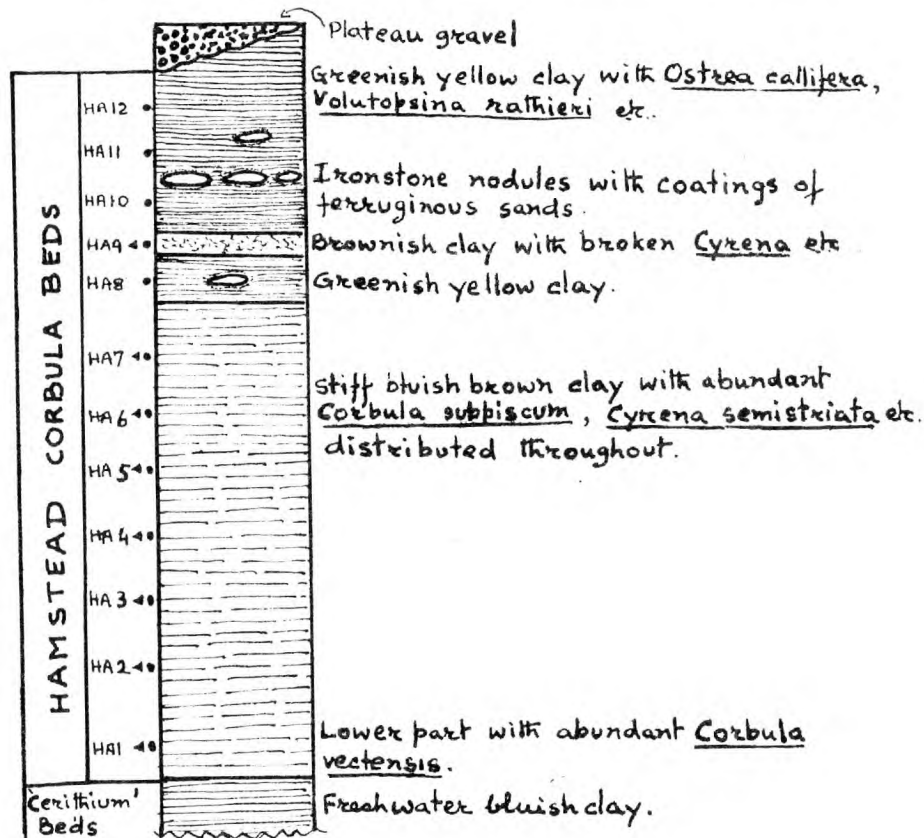
Scale 6 ft = 1 inch.

LEGEND

- Sample Horizons.
- ◄ Foraminifera present.



(b) VERTICAL SECTION OF THE HAMSTEAD CORBULA BEDS
AT HAMSTEAD HILL. Scale 4 ft = 1 inch.



fossiliferous clay which overlies the ferruginous sand may doubtfully be classed with the marine deposits, as they are completely devoid of fossils.

(iii) The Bembridge Marls:- The freshwater marls contain abundant freshwater shells - Viviparus lentus (Solander), Melania acuta (J.Sowerby), Nystia duchasteli (Nyst) being common. Besides Whitecliff Bay, the Bembridge marls are also exposed at St. Helens, Hamstead cliff, and between Cowes and Newtown. The thickness varies from 70 feet in the west to about 120 feet in the east. (White 1921, p.132).

(d) HAMSTEAD BEDS.

The Hamstead beds form the uppermost division of the late Palaeogene sediments and are best exposed in the type section in Hamstead Hill, about midway between Newtown and Yarmouth. Prestwich (1846, p.56) was the first to show that this series of estuarine and freshwater deposits overlies the whole 'Fluvio-Marine' series and contains a distinct fauna. The marine Corbula beds forming the uppermost 20 feet of this series, however, were first discovered by Gibbs (Forbes, 1856, p.39).

The following classification is generally accepted and is adopted from the latest Geological Survey classification (Chatwin, 1948, p.73):-

- Marine clays ('Corbula Beds') with Corbula subpisum,
Terebralia plicata, Cyrena semistriata, Ostrea callifera,
Volutospina rathieri, etc. ----- 19½ ft.
- Upper estuarine and freshwater beds ('Cerithium Beds') with
Pirenella monilifera, Nystia duchasteli, Viviparus lentus,
Unio, Cyrena, etc. ----- 11¾ ft.
- Middle estuarine and freshwater beds, with Bayania fasciata,
Viviparus, Planorbis, Unio, Nystia, etc., and carbonaceous
seams with plant-remains. 'White Band' (clays and marls
with shells) at the base ----- 158¾ ft.
- Lower estuarine and freshwater beds, with Melania acuta,
Stenothyra [Nematura] pupa, Limnaea, Planorbis, 'Mya'
minor, Cyrena semistriata, etc. The 'Black Band', full
of Viviparus lentus and Unio, at the base ----- 65¾ ft.

Lower, Middle and Upper Estuarine and Freshwater Beds:-

The 'Black Band' (carbonaceous clay) at the base of the Hamstead series separates them from the underlying Bembridge Marls (Forbes, 1856, p.39). On the whole, there is little difference between the Hamstead Freshwater beds and the Bembridge marls. Almost all the fossils are common to both. Some authors even regard these lower beds as simply a different lithological stage of the Bembridge Marls. It is only in the Corbula Beds (20 feet), which are perhaps the most purely marine of the entire 'Fluvio-Marine' formation, that a fauna differing from that of the rest of the series is found.

Corbula Beds (see vertical section, Plate IVb):-

The basal portion of this marine bed consists of about 8-10 feet of stiff bluish-black clay, full of such marine shells as Corbula subpisum J.Sowerby, Trebralia plicata Brug., etc., It contains a few bands of ironstone nodules in the upper part. In the lowermost 5 or 6 inches of these bluish clays, another species of Corbula (C.vectensis Forbes) is found and is confined to this zone. A few brackish-water species are also present. Overlying the bluish-black clay is a shelly band, full of fragments of Cyrena, Volutospina, etc. It is a yellowish-brown in colour and varies in thickness from 4" to 1 foot. It occasionally contains lenses of clay. The topmost beds are of greenish-blue clay (weathering yellow), which contains lenticular bands of compact nodular ironstone, coated with ferruginous sand. The most characteristic fossil is Ostrea callifera Lamarck, but it is not abundant. Locally, the uppermost beds are missing, owing to local erosion before the deposition of the overlying gravels. The thickness of the clays varies from 5 feet to 11 feet. At the locality where the samples were collected, the clays were only about 5 feet thick.

The Hamstead beds have been proved to occur at Alverstone Brick and Tile Works, Wooton, East Ashey, Dorehill, and in the Parkhurst Forest, and therefore occupy a much greater area than had previously been supposed.

III. PREVIOUS WORK ON THE AGE AND FOREIGN EQUIVALENTS OF THE 'FLUVIO-MARINE' FORMATION.

Inspired by the earlier work of Cuvier and Brongniart (1808) on the Tertiary strata of the Paris Basin, Thomas Webster in 1816 (Englefield, 1816) published the first description of the 'Fluvio-Marine' formation of the Isle of Wight. He designated the Headon Hill section as the type section and subdivided the beds in that section into three divisions on the basis of the included faunas:- The Lower Freshwater beds, (comprising all the freshwater deposits below the Middle Headon marine bed); the Upper Marine beds (including all the marine Middle Headon deposits); and the Upper Freshwater Beds, (comprising all the freshwater deposits lying above the latter).

Webster obviously regarded all the marine beds in the 'Fluvio-Marine' formation as being on the same horizon and grouped them all together as the "Upper Marine beds". He compared his three groups with the upper three groups of the five in the Parisian Tertiaries described by Cuvier and Brongniart.

Sedgwick (1822) observed the analogy between the "Upper Marine" or Middle Headon of Whitecliff Bay and the marine beds in Colwell Bay, and stated that all the species found in these beds in Whitecliff Bay, with the exception

of one oyster, occurred in the "Upper Marine" of Colwell Bay. He also showed that the beds of Hordwell cliff (on the mainland) belong to the Lower Freshwater and Upper Marine formation of Webster, and compared the two groups with the Grès Moyens or Grès de Beauchamp of the Paris Basin. The beds in Hamstead cliff were first described by Sedgwick, who grouped them all with the Upper Freshwater beds of Webster. Sedgwick also came to regard the marine beds of the Bembridge series as being equivalent to the "Upper Marine" group of Webster.

Buckland (1825) described a mammalian fauna from the Lower freshwater beds and showed it to be similar to that found in the Gypsum of Montmartre, thus establishing its general parallelism with the upper portion of the series seen in the Paris Basin. His conclusion was later confirmed by the work of Pratt (1835) and Owen (1841).

D'Archiac (1839, p.172) regarded the Lower freshwater beds as being of Upper Eocene age, and representing his Group IV (that of Calcaire siliceux); the Upper Marine beds (of Webster) and the Upper Freshwater beds as being of Lower Miocene age, and representing his Group V (Grès et sables supérieurs) and Group VI (Calcaire lacustre supérieurs) respectively.

Prestwich (1846, p.56) showed that the Estuarine and Freshwater beds exposed at Hamstead cliff were the highest in the 'Fluvio-Marine' formation and that they

contained a fauna distinct from that of the underlying beds.

In 1847 (p.398) he further stated that the "English Tertiaries in the Hampshire basin and to the west of London belong entirely to the Eocene period and that they can be divided into three great groups - characterised by peculiar mineral structure and organic remains". The Lowest group was stated to be argillaceous and to consist mainly of mottled clays with a few subordinate sandy beds. The London Clay was included here. The Central group was said to constitute the Bagshot and Bracklesham series, arenaceous formations with green sands. His Upper group included all the green marls, earthy limestones and siliceous sands of freshwater and fluvio-marine origin.

He concluded (p.399) that the entire 'Fluvio-Marine' series of the Isle of Wight is the fluvio-marine and freshwater equivalent of the upper part of the Calcaire Grossier of the Paris Basin, and accordingly ascribed them to the Upper Eocene.

Dumont (1851) studied the Older Tertiary strata of Belgium and compared them with those of England and Northern France. He regarded the Headon Hill sands as being equivalent to the upper stage of his Laekian system (the lower being equivalent to the Barton Clay), and the 'Fluvio-Marine' formation as representing his 'Système Tongrien'. He therefore correlated the 'Fluvio-Marine' series with the marine marls above the Gypsum of Montmartre (op.cit., p.17).

Hébert (1852) considered the freshwater formations of Hordwell to be the equivalents of those of Montmartre. However, he regarded the Middle Headon marine bed ('Venus Bed') of Colwell Bay as being higher and younger than that of the Headon Hill, and as representing the base of the Sable de Fontainebleau of the Paris Basin (the Limburg beds of Belgium and Mayence Basin).

Lyell (1852, p.279) gives a synoptic table of the Tertiary formations of Belgium and French Flanders with their British equivalents. He groups the *Système Rupélien*, and *Système Tongrien* (both *supérieur* and *inférieur*) of Dumont together as the Limburg Tertiaries and subdivided this group into Upper, Middle and Lower Limburg series. He correlated the 'Fluvio-Marine' formation of the Isle of Wight with the Middle series. The age of the formation was stated to be Upper Eocene.

In his classic work on the "Tertiary Fluvio-Marine formation" of the Isle of Wight, Forbes (1853, p.263; 1856) also considered the entire series to be of Upper Eocene age and suggested the following correlation with the European Tertiaries:-

- (1) The Headon Hill sands, and the Lower and Upper freshwater beds in Headon Hill, are, as maintained by Prestwich, equivalent to the upper part of the *Calcaire Grossier* of the Paris Basin.

- (2) The St. Helens or Osborne beds, (intermediate between the Headon series proper and the Bembridge Limestone), represented the 'Grès moyen' of the same area.
- (3) The Bembridge Limestone and Marls were the equivalents of d'Archiac's Gypseous series, or 'Calcaire lacustre moyen' with its associated beds, and of the Lower Tongrian of Belgium.
- (4) The Hamstead series (spelt throughout as 'Hempstead' series) are equivalent to d'Archiac's group of "Grès et Sables supérieur" (including Grès de Fontainebleau). They are also equivalent to the Middle and possibly the upper Limburg beds of Belgium.

He confirmed the views of Prestwich concerning the beds in the Hamstead cliff as being the highest in the 'Fluvio-Marine formation' and proposed the name Hamstead series for them. He proved that the marine and freshwater strata seen at Bembridge ledge were not, as had previously been supposed, the equivalents of those of Headon Hill, but occupied a distinctly higher horizon.

In 1854, Beyrich first proposed the term Oligocene for certain beds in Northern Germany, intermediate in character and position between the Upper Eocene and Lower Miocene. His view that these beds were distinctly separable on palaeontological and stratigraphical grounds from those above and below was later confirmed by the researches of Sandberger,

von Koenen, von Hantken, and others.

Sandberger (1862) considered the upper formation of Hamstead Hill to be the exact equivalent of the beds exposed at Weinheim, Jeurres and Bergh (Rupélien inférieur of Dumont), and the freshwater limestone of Bembridge and Sconce to be equivalent to the beds seen at Buxweiler (Alsace), Abstadt (Baden) and possibly also to the freshwater limestone of Castelnandary in France. He also pointed out that the Middle Headon beds of Headon Hill and Colwell Bay probably belong to the level of Dumont's 'Tongrien inférieur' and 'Tongrien supérieur'.

Von Koenen (1864, p.101) studied the Brockenhurst fauna of the New Forest area and compared it with that of the Lower Oligocene of Belgium and Northern Germany. He pointed out the contemporaneity of the Brockenhurst beds and the Middle Headon beds at Whitecliff Bay, and regarded them as all belonging to the Lower Oligocene (Système Tongrien inférieur). His view concerning the contemporaneity of these beds was later confirmed by the work of Codrington (1868).

In later papers (1867a, p.507; 1867b, p.31) von Koenen proposed the following correlation:-

	England	Belgium	Germany
Upper		Elsoo, near Maestricht	Cassel ^s , Freden, Bünde, Crefeld, Sternberg.
Middle	Hamstead and Bembridge series	Système Rupélien Système Tongrien supérieur	Hermsdorf, Söl- ingen, Stettin, Cassel, Bünde
Lower	Headon series Brockenhurst beds.	Système Tongrien inférieur	Lattorf, Wester- geln, Helmstadt, Bünde, etc.,

Duncan (1866) studied the corals from the Brockenhurst beds and amply confirmed the earlier views of von Koenen, Sandberger and others that these beds should be ascribed to the Oligocene.

Judd's views regarding the foreign equivalents of the 'Fluvio-Marine' formation of the Isle of Wight were essentially the same as those of von Koenen, and he strongly advocated the use of the term "Oligocene" for the age of the British beds (1880, p.150; 1882). He followed Hébert (1852), however, in regarding the marine beds of Colwell and Totland Bays as being younger in age than the Headon Hill marine bed. He proposed the following modified classification of the 'Fluvio-Marine' formation (1880, pp.168-169):-

- (1) Abandonment of the three fold subdivision of the Headon series and the extension of the name of the

Headon series, under the name of Headon group, to include all the beds between the Barton and Brockenhurst series.

- (2) The Brockenhurst beds of the type area at New Forest (on the mainland) were regarded as equivalent to the Middle Headon beds of Whitecliff and Colwell Bays, and were grouped under the former name.
- (3) The application of the name "Bembridge group" to all the beds between the Brockenhurst and Hamstead series (marine) to include strata both above and below the Bembridge series of Edward Forbes, and also those at the base of the Hamstead and the Osborne beds.
- (4) The abandonment of the group of the "Osborne and St.Helen's series".
- (5) The inclusion in the Hamstead series of only the uppermost 100 feet of the beds at Hamstead cliff.

Judd's views concerning the relative ages of the Colwell Bay and Headon Hill marine beds were strongly criticized by Keeping and Tawney (1881, p.108), Lucas (1882, p.103) and Fisher (1882, p.133). They offered ample stratigraphical and palaeontological evidence in favour of the older views of Forbes, von Koenen and others on the equivalence of the Colwell Bay and Headon Hill marine beds.

Gardner, Keeping and Monckton writing about the

Barton sands in 1888 (p.594), state that "the Barton series ends at this horizon, where all that is most characteristic of the Barton fauna finally disappears. It is, indeed at this point, if anywhere in England, that any approach to a separating line between Eocene and Oligocene can be drawn".

In the light of the latest views concerning the use of the term "Oligocene", Prestwich (1888, p.108) re-oriented his ideas on the Tertiary beds of the Hampshire Basin, and came to regard the Barton beds, Wemmelian system (Belgium) and Grès de Beauchamp (Paris Basin) as being equivalent to each other and to be of Upper Eocene age.

Leriche (1905, p.391), D¹olfus (1909a; 1909b, pp. 107-112) and Reid and Groves (1921), on the other hand, consider the entire Headon series to be of Upper Eocene age (part of the Marinesian or Bartonian). Reid and Groves (op.cit., p.176) state "The Headon Beds, though placed by British geologists, following Judd, in the Oligocene, and lithologically more closely allied to the Oligocene above than to the Barton Beds below, are in reality on the same horizons as the Calcaire Grossier of the Paris Basin, and this for some time has been recognised. As the Charophyta also, so far as they can yet be compared, lead us to the same conclusion, we shall not hesitate to speak of the Headon beds as the Upper Eocene".

Boussac (1907), Stamp (1921), Wrigley^y and Davis (1937) agree that the Middle Headon Beds mark the base of the Oligocene.

Boussac (p.409) states:- "L'oligocène, essentiellement caractérisé par la grande transgression sur le continent nord-européen, comprendra les couches où on trouve la faune Cryptogène amenée par cette transgression; on le fera donc débiter par les couches moyennes de Headon en Angleterre, et par les marnes supragypseuses en France"

Stamp (op.cit., p.151), using the concept of Cycles of Sedimentation, remarks that the Bartonian cycle closes with the Lower Headon, and that the Middle Headon marine beds, mark the beginning of a new cycle. His correlation is as follows:-

	<u>Paris Basin</u>	<u>Hampshire</u>
OLIGOCENE	Marls above the Gypsum	Middle Headon Beds (including Brockenhurst beds).
EOCENE- { Bartonian { (Ludian (s.s.) Bartonian (s.s.)	Ludian marls with Gypsum Sands of Marines and Cresne.	Lower Headon beds and Barton sands. Barton Clay

On the other hand, White (1921), Denizot (1940), Chatwin (1948), and Wells and Kirkaldy (1952), regard the Lower Headon beds as part of Oligocene.

Most of the authors seem to be agreed upon the use of the term Oligocene for either part or whole of the 'Fluvio-Marine formation.' The question remains, however, as to

where the dividing line should be drawn; whether as low as the base of the Lower Headon, at the base of the Brockenhurst beds, or at a still higher level in the sequence.

It will be seen that most authors are reluctant to split the uniform and homogeneous group of Headon beds, and as such regard the entire group as either Eocene or Oligocene. There are others who prefer to regard the Middle Headon beds as the base of the Lower Oligocene. More recent continental classifications even restrict the term Oligocene to the uppermost portion of the Hamstead beds, and include the lower beds with the Eocene (Chatwin, 1948, p.71).

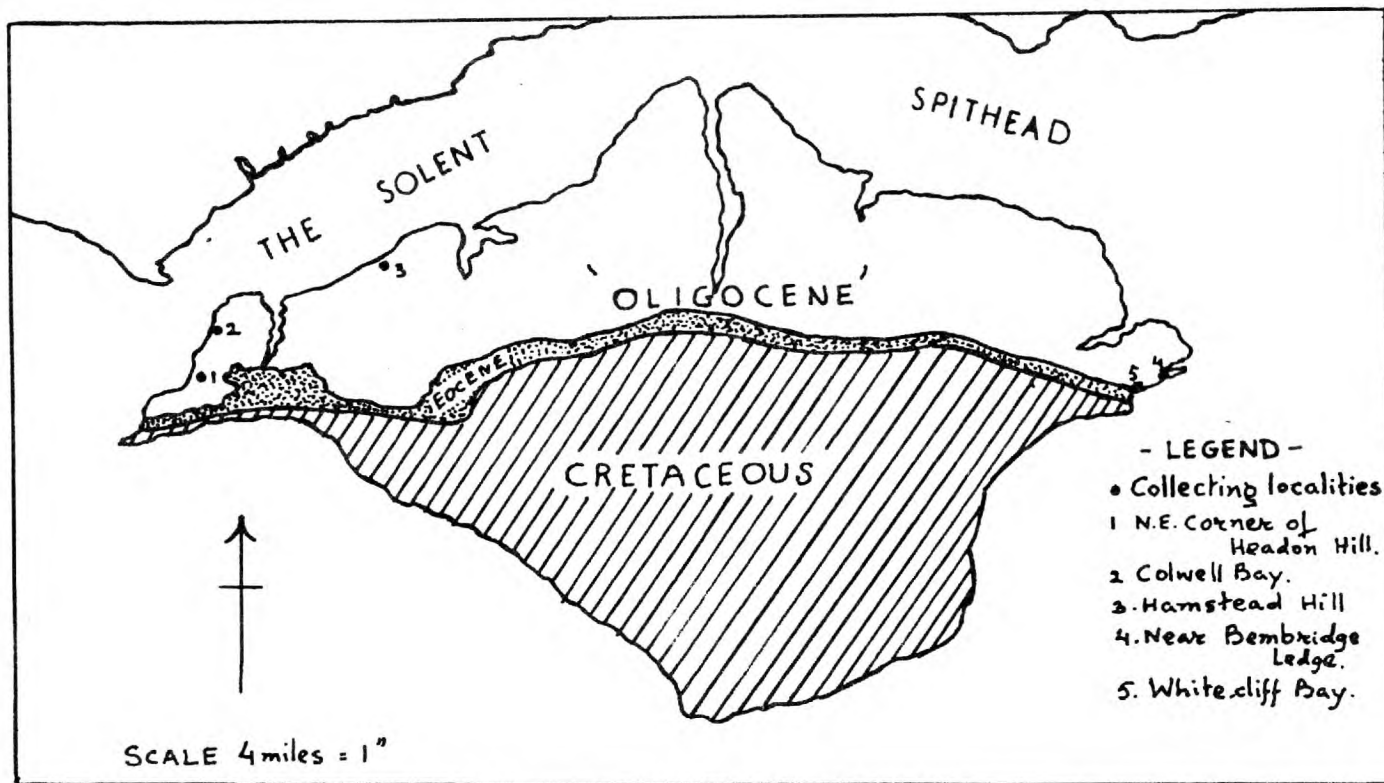
IV. PREVIOUS WORK ON THE FORAMINIFERA OF THE LATE
PALAEOGENE SEDIMENTS.

It will be seen from small number of references mentioned below that very little work has been done on the foraminiferal fauna of the late Palaeogene sediments of the Isle of Wight. This may be partly due to the fact that a great thickness of the sediments is of fresh- or brackish-water origin. The marine beds, also, are not very productive.

The earliest reference to foraminifera from the 'Oligocene' beds is made by T.R.Jones (1882). The only foraminifera mentioned as being in the Edwards Collection are Quinqueloculina hauerina d'Orbigny, from the Hamstead beds, and some rolled specimens of Alveolina from the 'Fluvio-Marine' Headon beds; there are also some Chara fruits and marine ostracoda from the Headon beds.

Chapman (1902, p.274) wrote that "In this country the Oligocene is not so productive, since the beds are for the main part of freshwater or fluvio-marine character. From the Isle of Wight a small series, chiefly represented by Mil/iolina and Polymorphina has been obtained by the writer."

Jackson (1925, p.343) mentions Quinqueloculina hauerina from the Brockenhurst beds, as being in the Sandown Museum, Isle of Wight.



MAP OF THE ISLE OF WIGHT SHOWING THE THREE MAIN GEOLOGICAL DIVISIONS & THE LOCALITIES FROM WHICH THE MATERIAL FOR THE PRESENT STUDY WAS COLLECTED.

V. (A) LOCALITIES AND COLLECTION OF SAMPLES.

The material for the present study was collected mainly from the three marine beds in the late Palaeogene Sediments, namely the Middle Headon Marine beds (including the Brockenhurst bed), the Bembridge Oyster beds, and the Upper Hamstead Corbula beds. Although there are numerous other thin marine bands in the rest of the formation, they are too impersistent to be of any definite value.

Over a hundred samples were collected and the foraminiferal content examined. The localities listed below are indicated on the maps (see Plates V to VIII). Each sample represents a stratigraphical thickness of about 3 - 4 inches.

Locality 1. North-East Corner of Headon Hill. (Plate VIb).

28 samples (Nos. HH1 - HH28) were collected from the Middle Headon beds, at an average vertical interval of $1\frac{1}{2}$ feet. The top three samples were from the Upper Headon freshwater beds (see Plate I).

Locality 2. Colwell Bay. (Plate VIa).

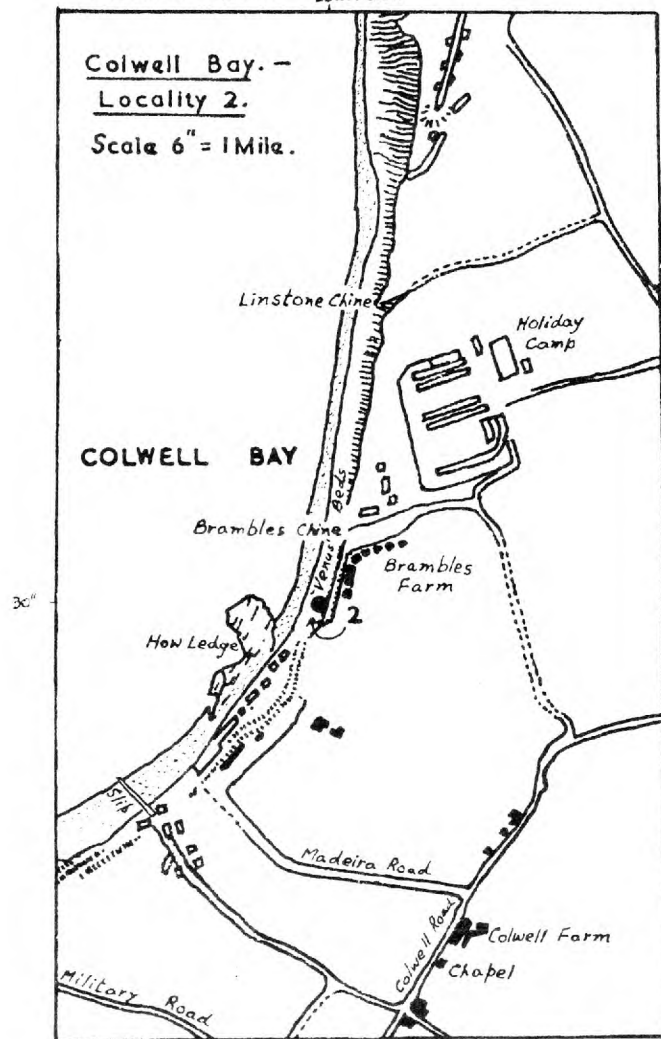
20 samples (Nos. C1 - C20) were collected from the Middle Headon beds, at an average vertical interval of $1\frac{1}{2}$ feet. (see Plate II).

Locality 3. Hamstead Hill. (Plate VII).

12 samples (Nos. HAI - HAI2) were collected from the uppermost marine Hamstead Corbula beds - 3 from the upper

PLATE VI a. LON. 1°32'W

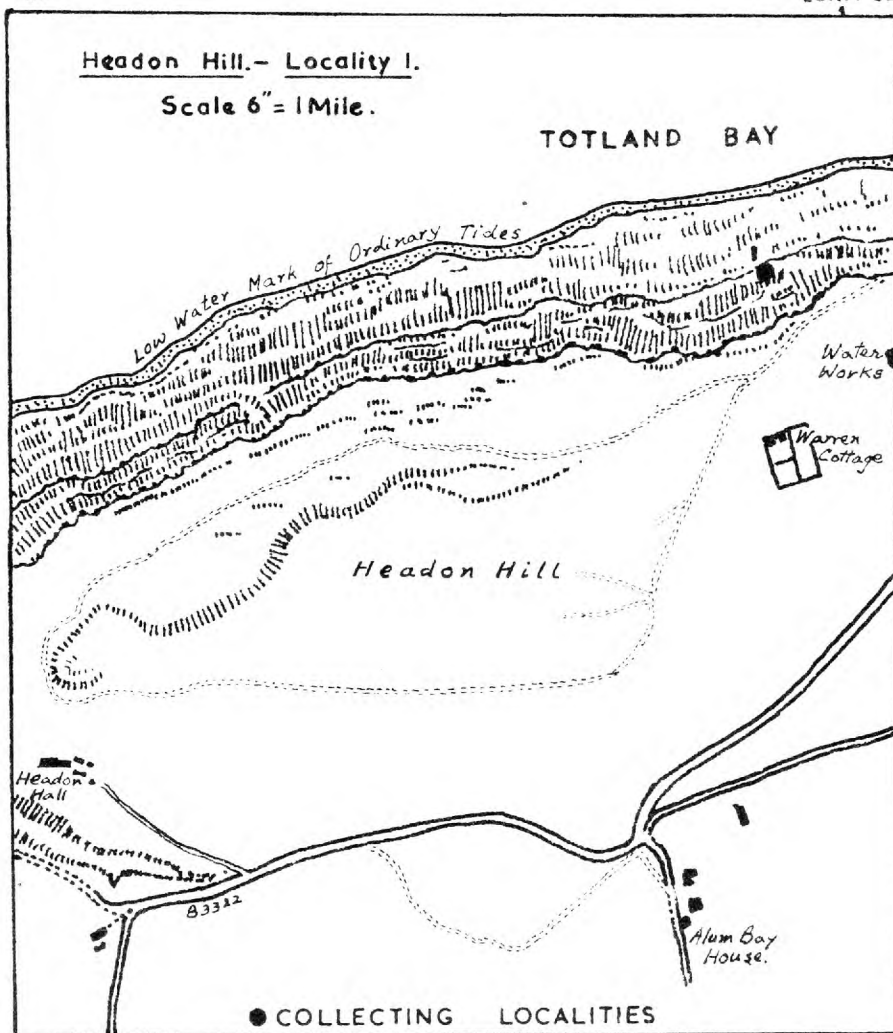
Colwell Bay. -
Locality 2.
Scale 6" = 1 Mile.



b.

LON. 1°32'W.

Headon Hill. - Locality 1.
Scale 6" = 1 Mile.



LAT.
50°40'

bed of greenish yellow clay with Ostrea callifera; 1 from a 6" band with broken Cyrena semistriata; and the remainder from the bluish-brown clay with Corbula subpisum (see Plate IVb).

Locality 4. Near Bembridge Ledge (Whitecliff Bay)(Plate VIII).

8 samples (Nos. B1 - B8) were collected from the Bembridge Oyster beds at an average vertical interval of 10". No samples were collected from the 3 feet thick white marls overlying the compact Bembridge Limestone, as they contain only freshwater shells (see Plate IVa).

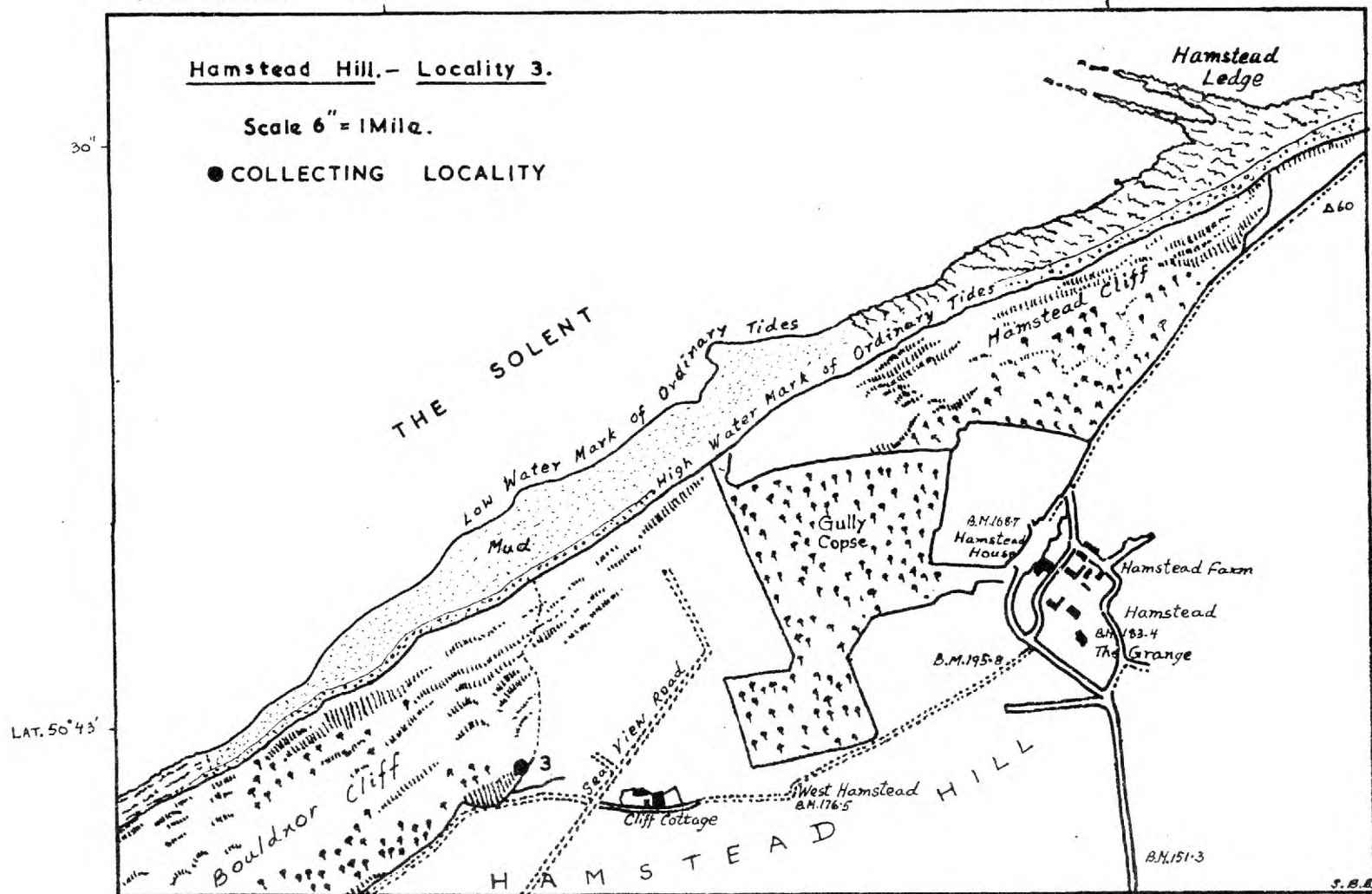
Locality 5. Whitecliff Bay. (Plate VIII).

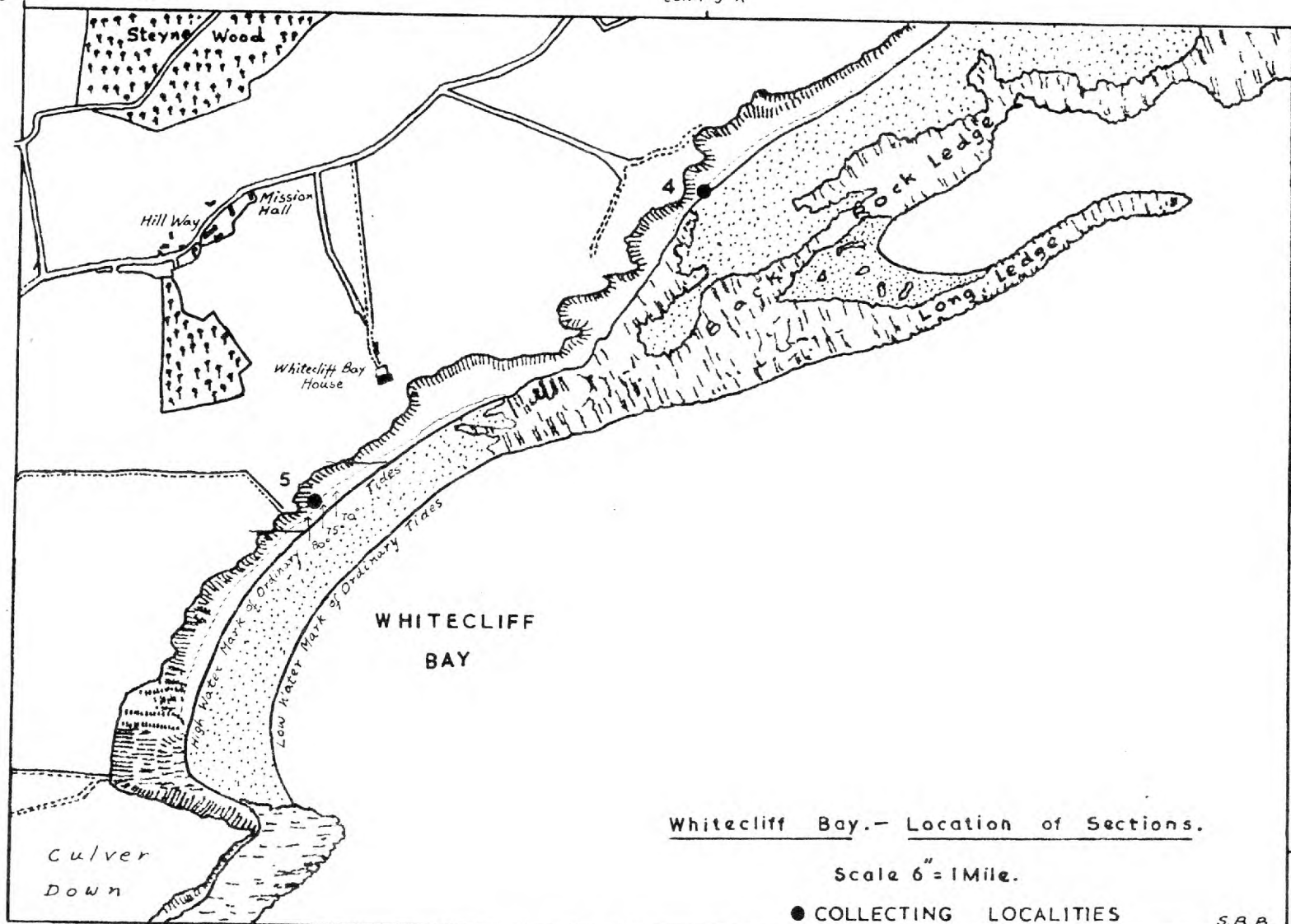
A total of 39 samples (Nos.W8 - W46) were collected from the Middle Headon beds (including the Brockenhurst bed). The exact positions are shown on the Whitecliff Bay stratigraphical column (Plate III). The deposits are almost vertical at this locality, and the samples were spaced out horizontally along the seashore (about 4 feet above high tide level). Of the 39 samples, 11 were collected from the Lowest Brockenhurst beds, 9 from the greenish sands (76 feet thick and unfossiliferous), and the rest from the overlying so-called 'Venus Beds'.

Hamstead Hill. - Locality 3.

Scale 6" = 1 Mile.

● COLLECTING LOCALITY





30°

LAT. 50° 40'

S.B.B.

(B) LABORATORY PROCEDURE AND METHODS OF STUDY.

An approximate weight of 55 grammes of each sample was boiled with Sodium carbonate and washed through a nest of sieves. No specific quantity was used since quantitative statistical work in relation to grain size was not undertaken. Clay samples were broken into small fragments before boiling, but this was unnecessary in the case of the sand samples. Three sieves (of 20, 120 and 200 mesh B.S.M) were used and the residues from each fraction were dried separately. The fractions were not re-sieved after drying. The foraminiferal assemblages were removed by flotation in Carbon tetrachloride. The iron pyrites casts of foraminifera (from the 'Barren sands') were separated from the mineral grains by using Tetra-bromoethane. Although the majority of foraminifera were separated from the mineral grains by these methods, a small number of broken and badly preserved specimens were still left in the residue. These were, however, separated by means of a sable brush.

The concentrate of foraminifera obtained by the Carbon tetrachloride separation was spread uniformly on a black bottomed slide with squares marked in white ink. The foraminifera were then systematically removed from the numbered squares. In this way all the foraminifera in the concentrate were picked and transferred to slides for subsequent identification and study. In the case of samples

containing super-abundant foraminifera, smaller quantities of the concentrate were used. The picking of the foraminifera was done by means of a fine 00 sable brush.

Although the foraminifera were removed from the different fractions separately the total number of foraminifera in each sample has been calculated, and also the percentages of different species in the assemblages. The >20 fraction in each sample was devoid of foraminifera.

The initial/^{outline}drawings of the foraminifera were made with the help of an eyepiece micrometer, and were later shaded with a soft pencil. The shaded drawings thus obtained were later photographed and reproduced to the desired size.

VI. CLASSIFICATION AND SYSTEMATIC STUDY.

In this work, Cushman's system of classification (1948) has been followed in its entirety. It is the most widely accepted classification, and therefore facilitates comparison with the works of other authors.

Over 60 species and varieties were found in the marine beds of the late Palaeogene sediments, and are described in the following pages. Though the fauna is limited in the number of species, the number of individuals of some species is fairly large. The following new species and varieties are described:-

Nonion laeve (d'Orbigny) var. minor-excavata.

Buliminella carteri.

Bulimina simplex Cushman and Parker var. colwelli.

Discorbis bembidgi.

Pararotalia subinermis.

Pseudoparrella oveyi.

It is intended to deposit at a later date all the new species and varieties in the Palaeontological collection at the British Museum (Natural History).

In the following pages, the various families and sub-families are arranged in systematic order following Cushman's classification. The genera, however, together with species and varieties, are arranged alphabetically.

The synonymies are arranged chronologically, and only

the references to the first changes in generic names are mentioned. All the subsequent references under a particular combination have been omitted, unless they are important. In cases where complete and satisfactory synonymies have already appeared, these references are cited, followed by et syn., in order to avoid unnecessary repetition.

The ecological data of some significant Recent species (which also occur in the Isle of Wight Oligocene material), have been omitted from the distributions given in the systematic study, as a comprehensive account appears in Chapter VIII (see also Table 7).

The range of variation of some species is noted and illustrated, wherever it is considerable. Minor variations, however, are recorded in the descriptions accompanying each species. Comments on the two dimorphic generations are made only in those species in which it was possible to distinguish them.

In designating the geologic age of the type horizons, the terms 'Lattorfian' and 'Rupelian' are used for Lower and Middle Oligocene respectively. 'Lattorfian' is used, because it is more precise than 'Tongrian', which has had several meanings in the past. The equivalent 'Sannoisien' is not based upon a good marine fauna. 'Rupelian' is chosen because it has priority over 'Stampien' and has a wider currency.

The following are explanations for the terms used in describing the distribution of species in the systematic study:-

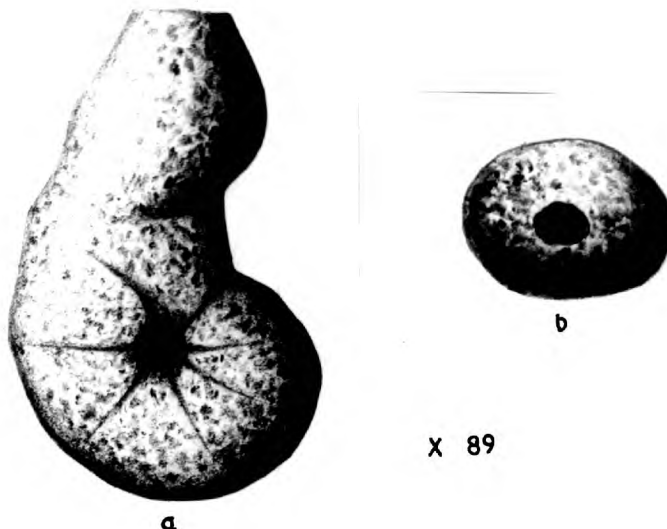
Rare = 1-5 specimens.

Frequent = 5-15 specimens.

Common = 15-30 " "

Abundant = Over 30 specimens.

Family: LITUOLIDAE.
 Subfamily: Haplophragmiinae.
 Genus: Ammobaculites Cushman, 1910.



Ammobaculites agglutinans (d'Orbigny).

Spirolina agglutinans d'Orbigny, 1846, Foram. Foss. Bass.

Tert. Vienne, p.137, pl.7, figs. 10-12.

Spirolina simplex Reuss, 1855, Sitzungsber d.k. Akad. Wiss.

Wien, vol.18, p.232, pl.5, fig.30.

Haplophragmium agglutinans (d'Orbigny) Brady, 1884, Rept.

Voy. Challenger, Zoology, vol.9, p.301, pl.32, figs.

19-26.

Ammobaculites agglutinans (d'Orbigny) Cushman, 1910, U.S.

Nat. Mus. Bull.71, pt.1, p.115, fig. 176 (et syn.).

Haplophragmium agglutinans (d'Orbigny) Marks, 1951, Contr.

Cush. Found. Foram. Res., vol.2, pt.2, p.35.

Description:- Test free, somewhat compressed, planispiral in the early portion, later in a typically linear series;

Spiral portion with little more than a whorl visible, umbilici depressed, 5-6 chambers, very little inflated; uniserial portion with usually 3 chambers, slightly inflated, cylindrical in cross section, sutures somewhat distinct, depressed, gently curved in the coiled portion, later straight; wall arenaceous, the amount of agglutinating material varying; aperture terminal, small rounded opening, simple.

Dimensions:- Length 0.74 mm.; breadth 0.46mm.; thickness 0.27 mm.

Distribution:- The species was originally described by d'Orbigny (loc.cit.) from The Miocene of the Vienna Basin, Austria; Marks (loc.cit.) records it from Roth - Neusiedl, in the Vienna Basin. Spirolina simplex Reuss, from the Oligocene Cassel sands, Germany, is evidently the same as this species. It has also been recorded from the Eocene of the Limburg Province, Holland (van Bellen, 1946). It is doubtful whether the various Mesozoic records of this species by Khan (1950), from the Gault of Kent, and other authors are correct. According to Dr. T. Barnard (personal communication), the Jurassic forms, recorded as A.agglutinans (d'Orbigny) are quite different from the Miocene species, and should be assigned to A.fontinensis (Terquem). This may be true of ~~some~~ other records also.

The species has a wide geographical distribution in the present-day seas, being recorded from the Atlantic and Pacific Oceans (Brady, 1884; Cushman, 1910 and 1922); several localities in the Weddell sea, and Antarctic Ocean (Heron - Allen and Earland, 1922; Earland, 1933, -34, -36); off Kerimba Archipelago, East Africa (Heron Allen & Earland, 1914-15). The three records given below are from the seas around the British Isles and Ireland - Balkwill & Wright (1885); Chaster (1892); and Brady (1887). Hada (1936) records it from the brackish-water lakes of Japan.

It is very abundant in the two basal samples (HA1 and HA2) and rare in sample HA5, from the Hamstead Corbula beds, Hamstead Hill. The figured specimens are from sample HA1.

Remarks:- In the Oligocene material from the Isle of Wight, the species occurs in a very fragmentary state, the coiled planispiral portion being usually found preserved. From a total of over 600 specimens, only 3 or 4 were complete; were it not for these, this species might have been mistaken for a Haplophragmoides.

Family: VALVULINIDAE.
 Subfamily: Valvulininae.
 Genus: Clavulina d'Orbigny, 1826.



X 45

Clavulina angularis d'Orbigny.

Clavulina angularis d'Orbigny, 1826, Ann. Sci. Nat., Vol.7,
 p.268, No.2, pl.12, fig.7.

Clavulina angularis Cushman, 1937, Cush.Lab. Foram. Res.,
 Spec.Publ. No.8, p.19, pl.2, figs. 29-33. (et.syn).

Description:- Test elongate, nearly 4 times as long as broad; earlier portion triserial, later uniserial, triangular in transverse section throughout, except the last 2-3 chambers which are rounded and slightly inflated, chambers distinct, 9 in uniserial portion; sutures distinct, depressed, much more so in the last portion; wall finely arenaceous, smoothly finished, aperture terminal, large, with a prominent projecting tooth.

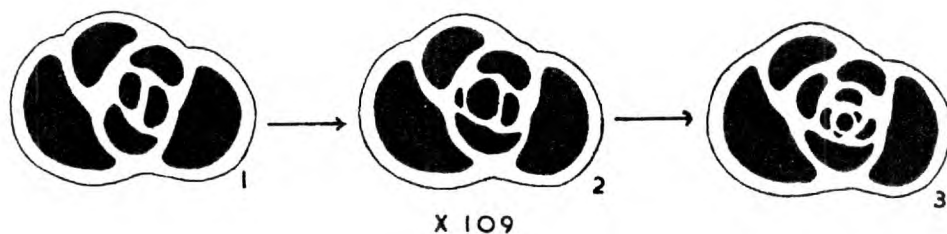
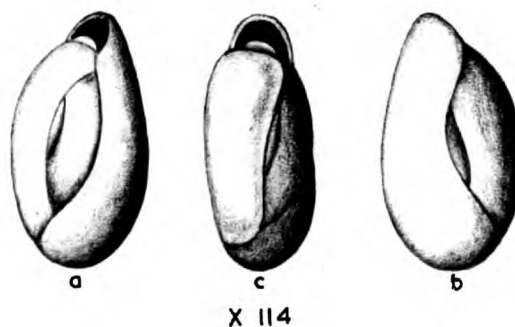
Dimension:- Length 1.6 mm; breadth 0.37 mm.

Distribution:- The type specimens of the species were from the coast of Corsica, in the Mediterranean. Similar forms have also been reported from the Pliocene and Oligocene of Italy. Allix (1930) records it from the Middle Oligocene of Chaussamairie, France. Heron-Allen and Earland (Halkyard, 1918) record it from the Eocene marls of Biarritz, France, but it is doubtful if this and other records are the same as d'Orbigny's species, as most of them are unaccompanied by figures or descriptions.

This species is apparently rare, and only single specimens were found in samples W8 and W16, from the Brockenhurst beds, Middle Headon, Whitecliff Bay. The figured specimen is from sample W8.

Family: MILIOLIDAE.

Genus: Miliolinella Wiesner, 1931.



Miliolinella oblonga (Montagu).

Vermiculum oblongum Montagu, 1803, Test. Brit., p.522,
pl.14, fig.9.

Triloculina oblonga (Montagu) d'Orbigny, 1826, Ann.Sci.Nat.,
vol.7, p.300, No.16, Modèles No.95.

Miliolina oblonga (Montagu) Terrigi, 1880, Atti Accad.Pont.
Nuovi Lincei, vol.33, p.51, pl.1, fig.2.

Triloculina oblonga (Montagu) Cushman, 1921 (1922), Contr.
Canad. Biol., p.15.

Miliolinella oblonga (Montagu) Cushman, 1940, Foraminifera,
their Classification and Economic use.
Massachusetts, p.163, pl.15, figs.6a-c.

Description:- Test small, elongate, somewhat oblong in shape, slightly compressed, periphery broadly rounded in end view; shell usually quinqueloculine but may be triloculine also, chambers somewhat inflated, last chamber broadest near the basal end; sutures distinct, depressed, arcuate, wall smooth, calcareous, imperforate, occasionally somewhat translucent; aperture large, somewhat oblique, with usually a large flat plate-like tooth.

Figures 1 to 3 represent serial transverse sections.

Dimensions:- Length 0.20 - 0.58 mm.; breadth 0.11 - 0.34 mm.; thickness 0.09 - 0.14 mm.

Distribution:- The type specimens of the species were from the Recent shore sand at Salcombe Bay, Devonshire, England. The species has a wide geographical distribution, and according to Brady (1884), it occurs in every part of the world. The following are some of the more important records from the present-day seas:- Cushman (1929), from the Atlantic Ocean; Cushman (1944), off Mt. Desert, New England Coast; Brady, Parker & Jones (1888), off Abrohlos bank; Cushman (1932), from several 'Albatross' stations in the Pacific; Natland (1933), from the Southern Californian region; Heron-Allen and Earland (1914-15), off Kerimba Archipelago, East Africa. Earland (1933, -34, -36) and Heron-Allen and Earland (1922) record the species from several localities in the Antarctic Ocean. It has also been recorded by several authors from around the British Isles - Brady (1865), off Northumberland

and Durham; Balkwill & Wright (1885), off Dublin, Irish Sea; Brady (1887), several localities; Heron-Allen and Earland (1916a), south-coast of Cornwall; west coast of Scotland (1916b) and off Plymouth (1930). Cushman (1949) records the species from off the Belgian coast.

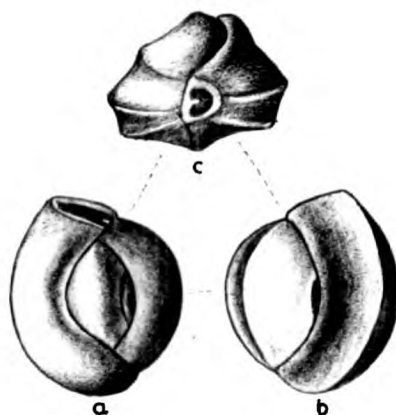
In the Fossil state, the species has been recorded from the London Clay (vide Brady, 1884). Its range is probably Eocene to Recent.

It is rare in a few samples from the Middle Headon beds of Headon Hill and Colwell Bay, but fairly common in sample W15, from the Whitecliff Bay section. It is rare to common in all samples from the Bembridge Oyster beds, and is irregularly distributed in the Hamstead Corbula beds. Figured specimens are from sample W15, Whitecliff Bay.

Remarks:- Brady's Challenger specimens (1884) of Miliolina oblonga were examined at the British Museum (Natural History), but these are not typical of the species. The test is very elongate and the tooth is small, bifid. They probably represent a different species.

Discussion:- In the Isle of Wight Oligocene material, the tooth is almost invariably broken or imperfectly developed. The stouter varieties approach M.^bsurrotunda (Montagu). It is doubtful if the new genus Triloculinella Riccio (1950) is valid, as there is no real boundary between the triloculine and quinqueloculine forms.

Genus: Quinqueloculina d'Orbigny, 1826.



X 104

Quinqueloculina bicarinata d'Orbigny.

Quinqueloculina bicarinata d'Orbigny, 1826, Ann. Sci. Nat.,
vol. 7. p.302, No.35.

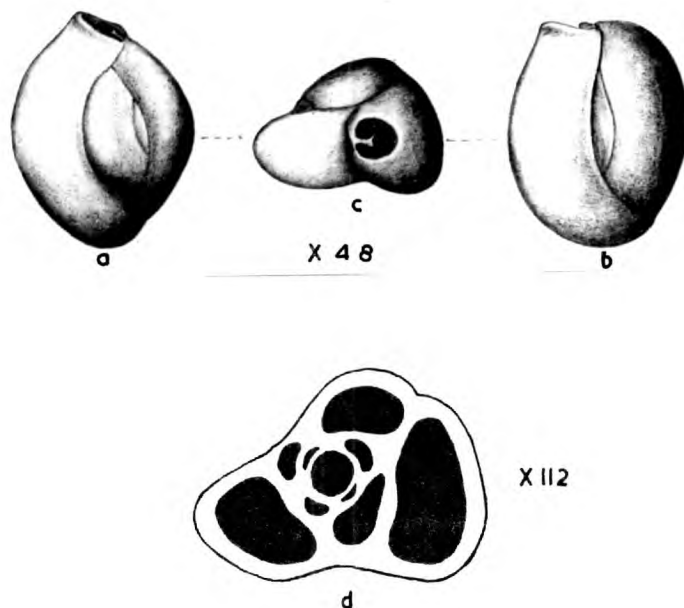
Quinqueloculina bicarinata Cushman, 1945, Cush. Lab. Foram. Res.,
Spec. Publ.No.13, p.16, pl.2, fig.9; pl.4, fig.2 (et syn).

Description:- Test minute, slightly longer than broad, almost oval in front view, somewhat rectangular in cross section, periphery bicarinate, subacute; chambers 5, rapidly increasing in size, the last two occupy more than 2/3 of the test; sutures distinct, slightly depressed, wall calcareous, smooth, imperforate; aperture fairly large, somewhat oval in shape, with a simple tooth.

Dimensions:- Length 0.25 mm.; breadth 0.20 mm.; thickness 0.16 mm.

Distribution:- D'Orbigny's types were from the Adriatic Sea, near Rimini, and from the Pliocene at Castel Arquato, Italy. Terquem (1878), recorded this species from the Pliocene of the Isle of Rhodes.

A few specimens (one of which is figured here) referable to this species were found in sample W15 from the Brockenhurst beds, Whitecliff Bay.



Quinqueloculina impressa Reuss var. cognata
(Bornemann)

Quinqueloculina cognata Bornemann, 1855, Deutsch Geol. Ges.,
Zeitschr, vol.7, No.2, p.350, pl.19, figs. 7a-c.

Quinqueloculina impressa Reuss var. cognata (Bornemann)

Hagn and Hölzl, 1952, Geologica Bavarica, Bayer.Geol.
Landesamt. No.10, p.87.

Description:- Test of medium size, slightly longer than broad, somewhat oval in front view; roughly triangular in cross section, periphery broadly rounded, with convex sides, one side being more so than the others, sometimes even flat; chambers distinct, rapidly increasing in size; sutures distinct, depressed; wall with somewhat roughened appearance; aperture large, circular, with a stout bifid tooth.

Figure 'd' is a transverse section.

Dimensions:- Length 0.30 - 0.71 mm.; breadth 0.25 - 0.60 mm.; thickness 0.18 - 0.50 mm.

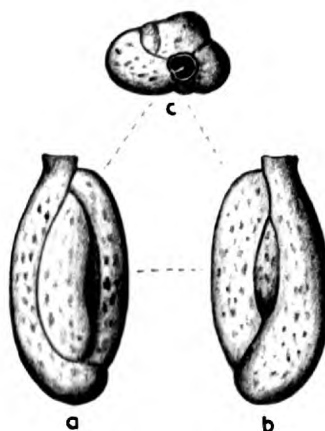
Distribution:- Bornemann originally described the species from the Middle Oligocene, Septarienthon, of Hermsdorf, Germany. Paalzow's figures (1924) of Q. impressa Reuss, from Cerithien sands of Offenbach, appear to be identical with the present species. Weber (1938-39) records it from the Middle Oligocene of Darnstadt and Heidelberg.

The species is restricted to the Brockenhurst beds, Whitecliff Bay, where it is rare to common in three samples (W15, W32, W33). The figured specimens are from sample W15.

Remarks :- The Isle of Wight specimens are identical with topotype specimens from the Middle Oligocene of Hermsdorf, Germany, kindly lent by Dr. Herbert Hagn of Munich University.

The variety is closely related to the typical species, and no evidence of dimorphism was noticed.

The specimens are apparently all magalospheric.



X 53

Quinqueloculina pertusa Terquem.

Quinqueloculina pertusa Terquem, 1882, Mém.Soc.Géol.

France, sér.3, vol.2, p.183, pl.20, figs. 5a-c.

Quinqueloculina pertusa Le Calvez, 1947, Serv.Carte Géol.

Mém., Paris, I, p.13, pl.1, figs.16-18 (et syn.).

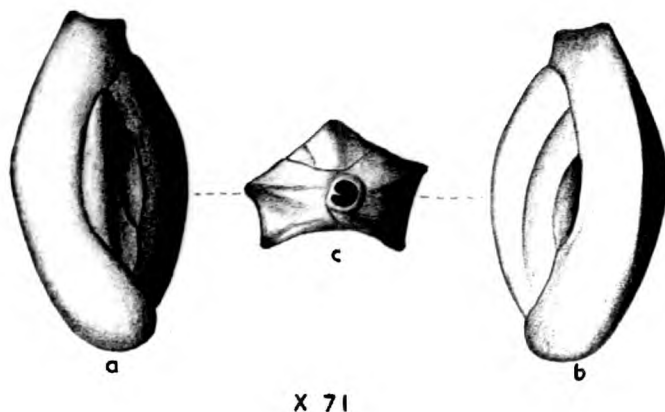
Description :- Test of medium size, elongate, slightly more than twice as long as broad, periphery broadly rounded, basal end slightly projecting, apertural end projected into a small neck; chambers elongate, slightly inflated; sutures distinct, depressed, curved; wall smooth, except for minute lozenge-shaped depressions arranged over the test in an oblique pattern; aperture at the end of a neck, circular, with a faint lip, tooth simple, somewhat clavate.

Dimensions:- Length 0.34 - 0.62 mm.; breadth 0.18 - 0.32 mm.; thickness 0.14 - 0.25 mm.

Distribution :- Terquem's types were from the Middle Eocene in the vicinity of Paris, France. Le Calvez (1947), records it from the following localities:- Villiers - Saint - Frederic, near Evreux, Eure: Mecringes, near Meaux, Seine et Marne: and Septeuil, near Mantes, Seine et Oise, France.

A few specimens referable to this species were found in sample W15, from the Brockenhurst beds, Whitecliff Bay, and one of them is figured here.

Remarks:- In the Oligocene specimens from the Isle of Wight, the lozenge-shaped depressions are not so pronounced as in the Eocene specimens from the Paris Basin.



Quinqueloculina juleana d'Orbigny.

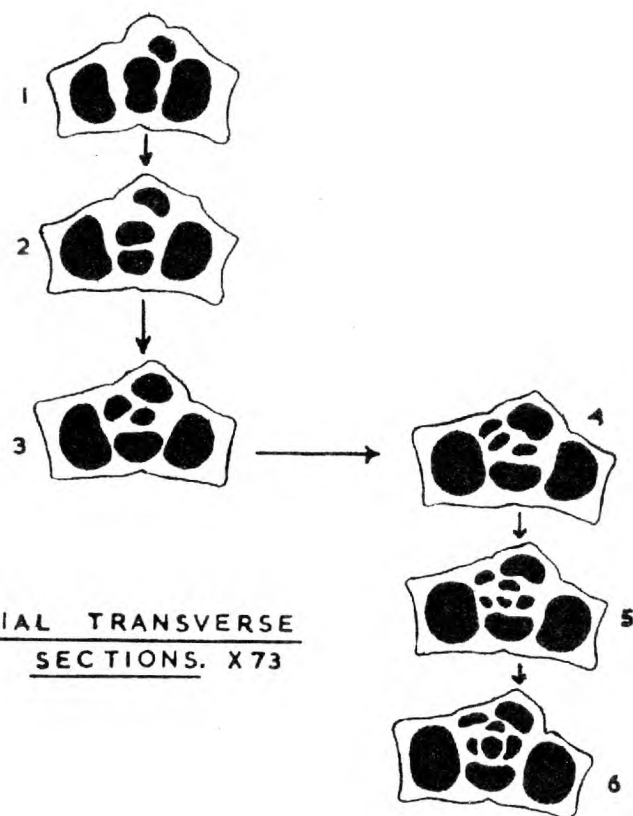
Quinqueloculina juleana d'Orbigny, 1846, Foram. Foss. Bassin
Tert. Vienne, p.298, pl.20, figs. 1-3.

? Quinqueloculina contorta d'Orbigny, 1846, ibid., p.298, pl.
20, figs.4-6.

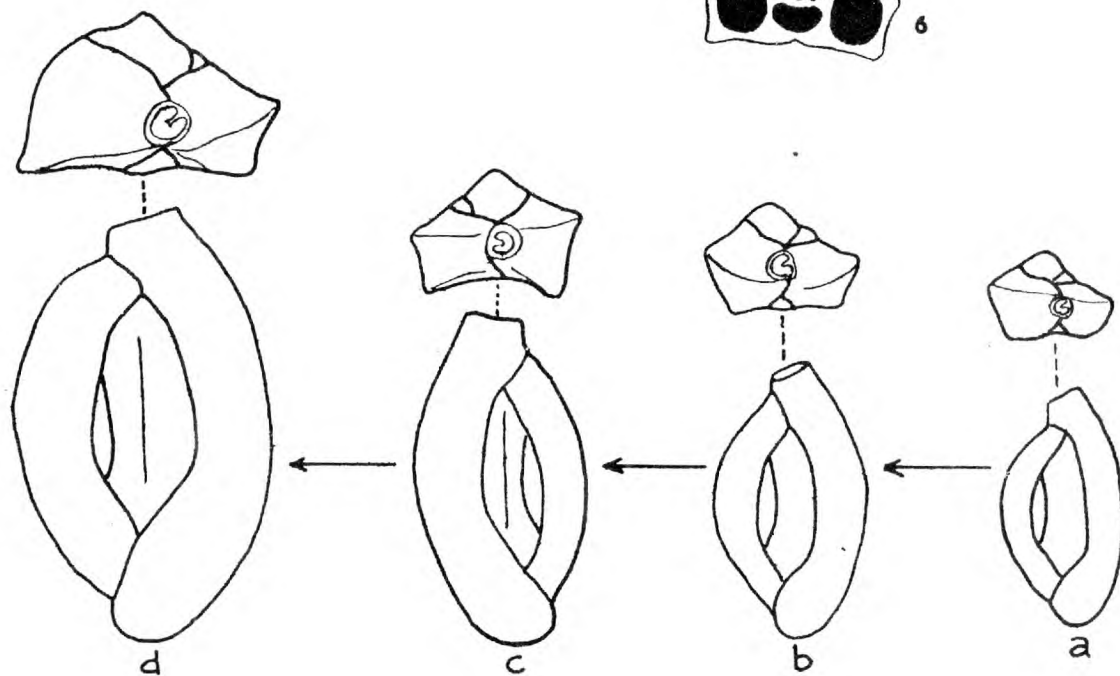
? Quinqueloculina mariae d'Orbigny, 1846, ibid., p.300, pl.
20, figs.13-15.

Quinqueloculina rugosa Marks, 1951, Contr. Cush. Found. Foram.
Res., vol.2, pt.2, p.39, partim, (non d'Orbigny, 1826;
Fornasini, 1905; Cushman, 1945.).

Description:- Test fairly large, about twice as long as
broad, somewhat rectangular in cross section, basal end
projecting, rounded, apertural end projecting into a short
neck; periphery bicarinate, with acute margins in adult



SERIAL TRANSVERSE
SECTIONS. X73



QUINQUELOCULINA JULEANA D'ORBIGNY, SHOWING
THE RANGE OF VARIATION X71

specimens; chambers somewhat inflated; sutures distinct, depressed; wall smooth, thick, imperforate; aperture large, circular, with a single simple tooth. The species shows considerable variation, especially in the peripheral keels and the length of the necks (see Plate IX, figs. a - d). In the young forms, the peripheral margins are less acute and slightly concave. With growth, however, the margins become more acute and in the adult specimens, there are two distinct keels, with concave sides. All intermediate forms between the young and adult stages were observed. Occasionally in some specimens, one peripheral keel is not well developed. Thin sections of these two contrasted types do not show any evidence of dimorphism. Figures I to 6 (Plate IX) show serial transverse sections.

Dimensions :- Length 0.32 - 0.96 mm.; breadth 0.18 - 0.46 mm.; thickness 0.10 - 0.27 mm.

Distribution :- The types of the species were from the Miocene of the Vienna Basin, Austria. The species has also been reported from the Miocene of Banat, Hungary (Karrer, 1868); the Miocene and Oligocene of Magdeburg (Franke, 1925); and the Middle Oligocene of Darnstadt and Heidelberg, Germany (Weber, 1938-39).

The species was found only in one sample (W12) from the Brockenhurst beds, Middle Headon, Whitecliff Bay, in which it is very abundant.

Discussion :- Marks (loc.cit.) lumped together a large variety of forms under Quinqueloculina rugosa d'Orbigny, 1826, some of which are definitely not synonymous.

Q.rugosa, from the Pliocene of Castel Arquato, Italy, is a very different species from the bicarinate forms (Q.badenensis - Q.mariae) recorded by d'Orbigny from the Miocene of the Vienna Basin, Austria. The Pliocene species, has, as the name implies, a roughened exterior. This is also evident from the descriptions given by Fornasini (1905, p.66) and Cushman (1945, p.16). The Miocene species (as figured by d'Orbigny), however, appear to be smooth. Cushman states with reference to Q.rugosa (op.cit. p.17), "There are numerous other records from various regions, evidently not all of the same species. Fornasini's figures are reproduced on our plate and a toptype specimen figured. The angles are not as definitely ridged as in Fornasini's figures but it has been shown many times that these tracings are not accurate in all details. The surface is slightly roughened". Cushman's figures of a toptype specimen (op.cit., pl.2, figs.15a,b) show a fairly large species, without any definite neck, and with faint ribs over some chambers. This last character is not apparent in d'Orbigny's figures. Marks does not mention having examined toptype specimens of Q.rugosa, and it is therefore presumed that he did not do so. The type specimens of the species, however, have been lost (vide d'Orbigny's

Index Cards issued by the Laboratoire de Micropaléontologie, Institut Français du Pétrole, Paris).

Although topotype specimens were not available, it is quite convincing from Cushman's figures, that Q.rugosa from the Pliocene, is not the same as the bicarinate Miocene species (Q.badenensis - Q.mariae), referred to in Marks' synonymy.

Another important point which Marks seems to have overlooked, is the fact, that Q.rugosa (1826), though the older name, was a nomen nudum until figured by Fornasini in 1905, and therefore cannot have priority over the Miocene species (d'Orbigny, 1846) referred to above.

Q.badenensis d'Orbigny (1846, p.299, pl.20, figs.10-12) is a stouter form, without any neck, and is most probably a different species. The type specimens of this species are figured in d'Orbigny's Index Cards, issued by the Laboratoire de Micropaléontologie, Institut Français du Pétrole, Paris.

Q.rodolphina d'Orbigny (op.cit., p.299, pl.20, figs.7-9) has three distinct keels and is therefore omitted from the present synonymy.

Q.contorta d'Orbigny (op.cit., p.298, pl.20, figs.4-6) has no neck and the sides are almost parallel. It appears probable that Q.contorta (0.5mm.) is a juvenile form of Q.juleana (1.0mm.), and the two are synonymous. (The dimensions given are after d'Orbigny.). Should that be

the case, the former name would take precedence. However, for the present, the Isle of Wight species is called Q.juleana, as it appears to be closely allied to d'Orbigny's figures of the species.

Q.mariae d'Orbigny (op.cit., p.300, pl.20, figs.13-15) is apparently a slight variant of Q.juleana, as it has only one keel on one side. A few specimens referable to this species were also found in the present material, and come within the range of variation of Q.juleana.

Quinqueloculina seminulum (Linnaeus).

Serpula seminulum Linnaeus, 1758, Systema Naturae, Edn.10,
p.786; 1767, ibid., Edn. 12, p.1624; 1788, ibid.,
Edn.13 (Gmelin, p.3739. No.2

Quinqueloculina seminulum d'Orbigny, 1826, Ann.Sci.Nat., vol.
7, p.303, No.44.

Miliolina seminulum Williamson, 1858, Recent Foram.Gt.Britain,
pp.85,86, pl.7, figs.183-185.

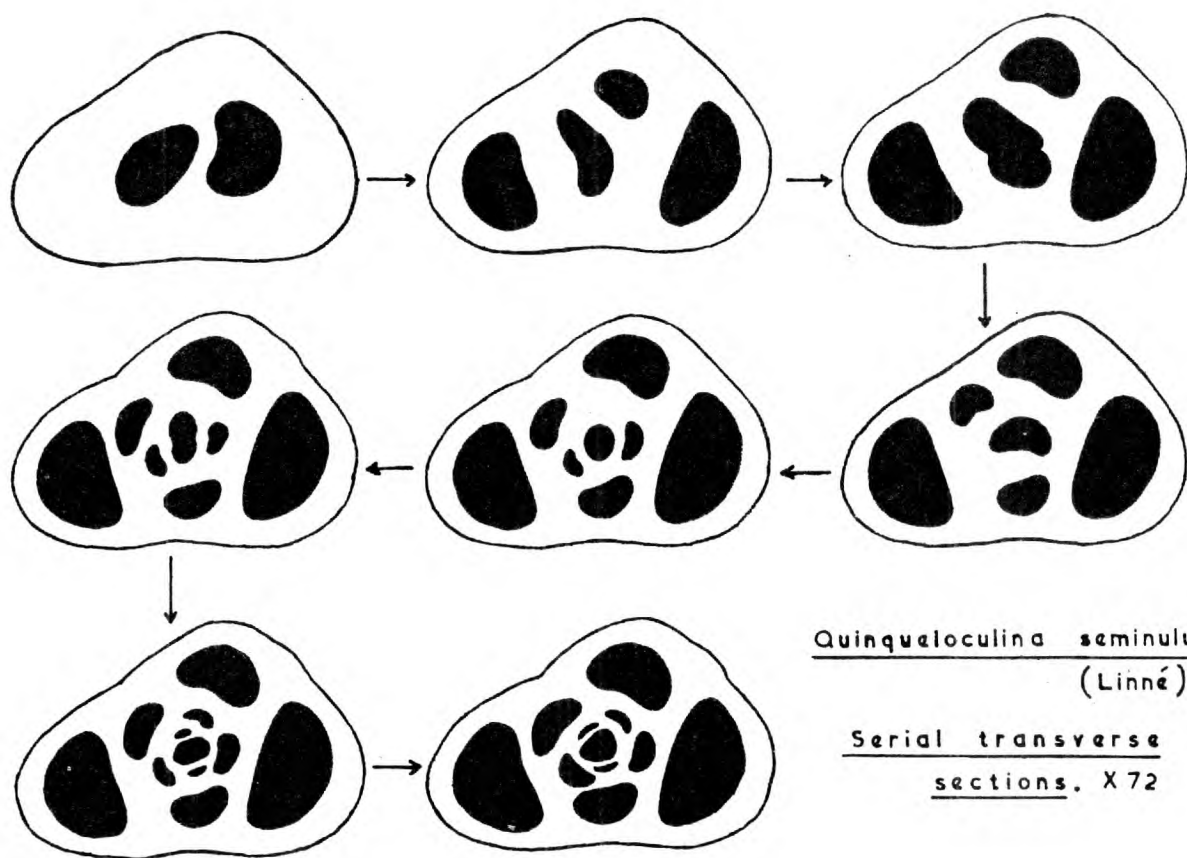
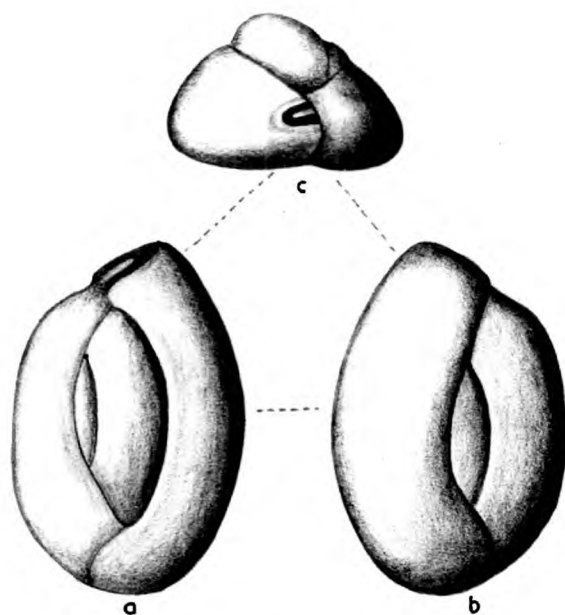
Miliolina seminulum Brady, 1884, Rep. Voy. Challenger, Zoology,
vol.9, p.157, figs.6a-c.

Quinqueloculina seminulum Cushman, 1917, U.S. Nat. Mus. Bull. 71,
pt.6, p.44, pl.11, fig.2.

Description :- Test fairly large, about $1\frac{1}{2}$ times as long as
broad, somewhat oval in outline, broadest and thickest in the
middle, triangular in cross section, with rounded angles;
5 chambers visible on the outside, arranged in a regular
quinqueloculine series; three visible on one side, four on
the other; sutures distinct, depressed, wall smooth;
aperture somewhat oval in shape, usually with a simple tooth.

The species shows an immense range of variation in
the shape and length of the test, amount of inflation
of the chambers, and the angularity of the chambers in
sectional view.

Dimensions :- Length up to 1.55 mm., breadth 1.0mm.,
thickness 0.62 mm.



Quinqueloculina seminulum
(Linné).

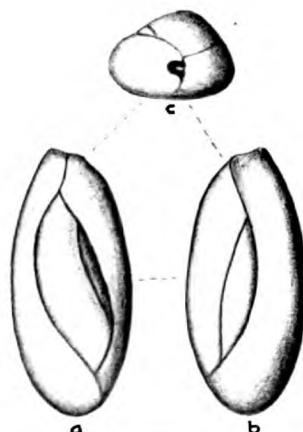
Serial transverse
sections. X 72

Distribution :- The type specimens were from the shore sand at Rimini, Italy. The species also occurs in the Pliocene of Castel Arquato, Italy.

Its distribution in the Oligocene sections of the Isle of Wight is irregular. Sometimes the species is only represented by a few specimens; in other cases it becomes abundant. However, it was found only in the basal parts of the Middle Headon beds of Colwell Bay and Whitecliff Bay sections, and in 3 samples from the Hamstead Corbula beds, Hamstead Hill. The figures specimens are from Sample W41, Middle Headon beds, Whitecliff Bay.

Discussion :- Q.seminulum, as already remarked, is a very variable species, and a large number of similar forms have been described under different names by various authors. Under these circumstances, it is difficult to give an adequate synonymy and an exact distribution. The range of the species, however, is Eocene to Recent. Brady (1884,p.157), in his synonymy has grouped together a large variety of forms, some of which are evidently very different from Q.seminulum (Linnaeus).

Remarks:- Brady's Challenger specimens were examined at the British Museum (Natural History) and are fairly typical of the species.



X 110

Quinqueloculina simplex Terquem.

Quinqueloculina simplex Terquem, 1882, Mém.Soc.Géol. France,
sér.3, vol.2, p.172, pl.18, figs.7-13.

Quinqueloculina simplex Le Calvez, 1947, Serv.Carte Géol.Mém.,
Paris, I, p.13, pl.1, figs.13-15.

Description:- Test elongate oval, slightly compressed, about $2-2\frac{1}{2}$ times as long as broad, somewhat triangular in cross section, with rounded periphery and convex sides; chambers elongate, 5; sutures distinct, slightly depressed; wall smooth, shiny; apertural end without any neck, aperture small, with a single simple tooth.

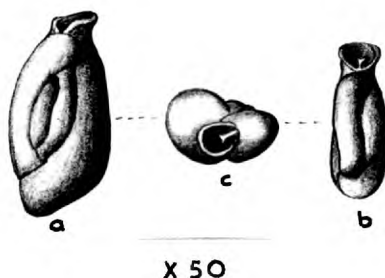
Dimensions :- Length 0.16 - 0.46 mm.; breadth 0.10 - 0.23 mm.; thickness 0.08 - 0.13 mm.

Distribution:- Terquem's types of this species were from the Middle Eocene of Vaudancourt, Paris Basin, France.

Le Calvez (1947), reports it from the following additional localities:- Mécringes, near Meaux, Seine et Marne; Fercourt, near Mouchy-le-Châtel, and Vaudancourt, near Chaumon-en-Vexin, Oise.

The species is very irregularly distributed in the Middle Heaton beds; it is rare to common in the Whitecliff Bay section and rare in one sample (C16) from the Colwell Bay section. It is also rare in one sample (HA3) from the Hamstead Corbula beds, Hamstead cliff. The figured specimens are from sample W41, Middle Heaton beds, Whitecliff Bay.

Remarks :- The species is identical with those from the Eocene of the Paris Basin (fide Le Calvez, personal communication).

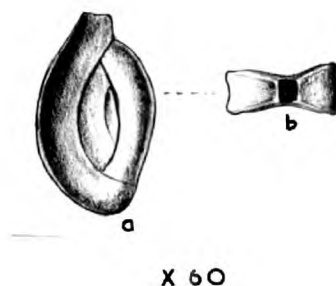


Quinqueloculina sp.indet.

Description :- Test small, compressed, somewhat rectangular in end view with rounded sides; chambers elongate, fairly rapidly increasing in size; sutures distinct, depressed, curved; wall smooth, calcareous, imperforate; aperture large, somewhat oval in shape, bordered by a thick lip, with a bifid tooth.

Dimensions :- Length 0.23 - 0.52 mm.; breadth 0.14 - 0.26 mm. thickness 0.10 - 0.18 mm.

Distribution :- The species was found only in one sample (HA3) from the Hamstead Corbula beds, Hamstead Hill, in which it is frequent.



Spiroloculina obscura Cushman and Todd.

Spiroloculina obscura Cushman & Todd, 1944, Cush. Lab. Foram.

Res., Sp. Publ. No. 11, p. 20, pl. 1, fig. 8; pl. 3,
figs. 22-25 (et syn.).

Description :- Test minute, $1\frac{1}{2}$ -2 times as long as broad, periphery slightly concave with sharp thickened angles; chambers few, rather indistinct in the earlier stage, the last two chambers comprising most of the test; the basal end of the last chamber projecting, the apertural end extending into a narrow, rather oblique neck; sutures distinct slightly depressed; wall smooth; aperture terminal, quadrangular, without a tooth.

Dimensions :- Length 0.37 mm. - 0.46 mm.; breadth 0.20-0.27 mm.
thickness 0.11 - 0.16 mm.

Distribution :- The type specimens of the species were from the Miocene of Dax, France. A similar form was recorded by Terquem (1882) from the Eocene of Vaudancourt and Chaussy, France.

A few specimens referable to this species were found in sample W 15 from the Brockenhurst beds, Middle Headon, Whitecliff Bay.

Genus; Triloculina d'Orbigny, 1826.

Triloculina trigonula (Lamarck).

Miliolites trigonula Lamarck, 1804, Ann. Mus., vol.5, p.351,
No.3.

Miliolites cor-anguinum Lamarck, 1804, ibid., p.351, no.2.

Triloculina trigonula (Lamarck) d'Orbigny, 1826, Ann.Sci.
Nat., vol.7, p.229, pl.16, figs. 5-9.

Triloculina austriaca d'Orbigny, 1846, Foram, Foss. Bassin
Tert. Vienne, p.275, pl.16, figs.25-27.

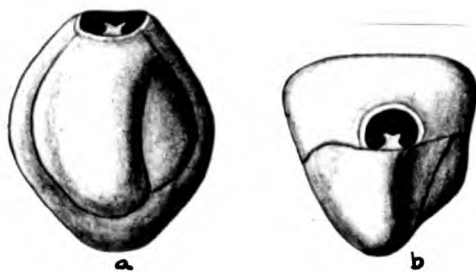
Triloculina gibba d'Orbigny, 1846, ibid., p.274, pl.16, figs.
22-24.

Miliolina trigonula (Lamarck) Williamson, 1858, Recent Foram.
Gt. Britain, p.84, pl.7, figs. 180-182.

Triloculina trigonula (Lamarck) Cushman, 1917, U.S. Nat. Mus.
Bull. 71, pt.6, p.65, pl.25, fig.3; Marks, 1951, Contr.
Cush. Found. Foram. Res., vol.2, pt.2, p.41 (et syn).

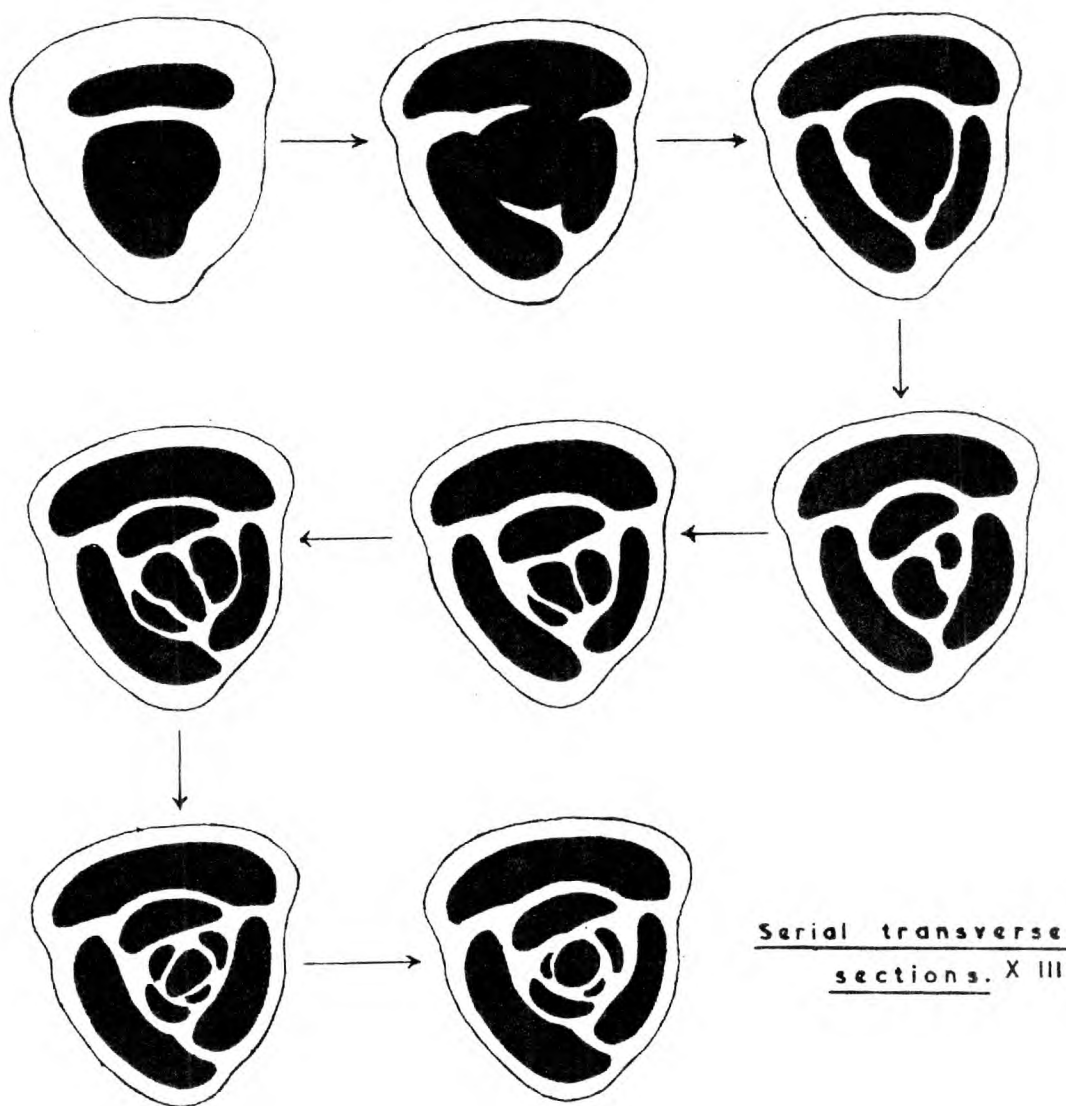
Description :- Test somewhat longer than broad, 3 chambers
(with rounded angles) visible in the adult; the last chamber
overlapping the other two with broadly convex sides; sutures
distinct, depressed; wall smooth; aperture circular, with
a short bifid tooth.

Dimensions :- Length 0.26 - 0.72 mm.; breadth 0.23 - 0.58 mm.;
thickness 0.18 - 0.58 mm.



X 96

Triloculina trigonula (Lamarck).

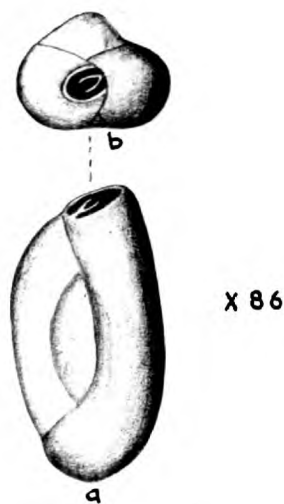


Serial transverse
sections. X III

Distribution :- Lamarck's types were from the Eocene beds at Grignon, Paris Basin. Identical forms are also reported from several other localities in the Paris Basin; the Bracklesham and Barton beds of Whitecliff Bay, Isle of Wight, England; Middle Eocene of Limburg Province, Holland (Van Bellen, 1946); from the Oligocene of Germany at Magdeburg and Bunde (Franke, 1925) and Darnstadt and Heidelberg (Weber, 1938-39). The species has also been reported from the Miocene of the Vienna Basin (d'Orbigny, 1846; Marks, 1951).

In the recent seas, the species is common in shallow waters of temperate zones (Fide Marks, 1951). From around the British Isles, the species has been recorded by a number of authors - Brady (1865, 1887); Balkwill and Wright (1885), from the Irish Sea; Chaster (1892), off Southport; Heron-Allen and Earland (1916a, 1916b, & 1930), from several stations off the south coast of Cornwall and west coast of Scotland. Other Recent records are :- Cushman (1926), off Porto Rico; (1929), from several stations in the Atlantic Ocean; (1932), from 2 stations in the Pacific Ocean; (1949) off Belgian coast; Heron - Allen & Earland (1914-15) from off Kerimba Archipelago; (1922), from several stations in the Antarctic Ocean; Norton (1930), from shallow waters of West Indian region; and Natland (1933), from the Southern Californian region.

The species is rare to common in 3 samples from the Middle Headon beds at Whitecliff Bay (W12, W15, & W18). The figured specimens (a,b) (Plate XI) are from sample W15.



Triloculina sp.cf. consorbina d'Orbigny.

Description :- Test of medium size, twice as long as broad, somewhat triangular in end view, periphery broadly rounded; chambers elongate, 2 visible on one side and 3 on the other, rather indistinct; sutures slightly depressed, curved; wall smooth, calcareous, imperforate; aperture large, oval, with a long bifid tooth.

The species may be questionably referred to T. consorbina d'Orbigny.

Dimensions :- Length up to 0.46 mm.; breadth 0.23 mm.; thickness 0.14 mm.

Distribution :- Rare to frequent specimens of this species were found in 3 samples (B1, B2 and B4) from the Bembridge Oyster beds, Whitecliff Bay.

Family: LAGENIDAE

Subfamily: Lageninae

Genus: Lagena Walker and Jacob, 1798.



x 70

Lagena sulcata (Walker and Jacob).

Serpula (Lagena) striata sulcata rotundata Walker and Boys,
1784, Testacea minuta rariora. p.2, pl.1, fig.6.

Serpula (Lagena) sulcata Walker and Jacob, 1798, Adam's
Essays, Kanmacher's edn., p.634, pl.14, fig.5.

Lagena sulcata (Walker and Jacob) Parker and Jones, 1865,
Philis.Trans., vol.155, p.351.

Lagena sulcata (Walker and Jacob) Cushman, 1913, U.S. Nat.
Mus., Bull.71, pt.3, p.22, pl.9, fig.2 (et syn).

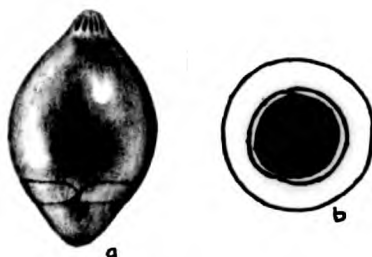
Description :- Test single chambered, subglobular, flask-shaped, with a small neck at the apertural end; wall finely perforate, ornamented with numerous raised costae running the length of the test and lower portion of the neck; apertural end broken.

Distribution:- The type specimens of the species were from the shore sand at Sandwich, Reculver and Sheppey Island, Kent, England. It has a wide geographical range, and has been

recorded by numerous authors from the present-day seas. In the Fossil state, it has been recorded from the Post-Glacial deposits of England (MacFadyen, several papers); Pliocene Crag of England (Parker, Jones & Brady, 1866-97); Miocene of the Vienna Basin, Austria (Marks, 1951); Oligocene of Mergel (Klahn, 1915); Middle Oligocene of Hermsdorf, Germany and Sub-Alpine Molasse (Hagn & Hölzl, 1952); and Gault of Kent (Khan, 1950).

One single specimen referable to this species was found in sample HH18, from the Middle Headon beds at Headon Hill, and is figured here.

Family: POLYMORPHINIDAE.
 Subfamily: Polymorphininae.
 Genus: Glandulina d'Orbigny, 1826.



x 117

Glandulina laevigata d'Orbigny.

Nodosaria (Glandulina) laevigata d'Orbigny, 1826, Ann.Sci.Nat.,
 vol.7, p.252, pl.10, figs.1-3.

Glandulina laevigata d'Orbigny, 1846, Foram. Foss. Bass. Tert.
 Vienne, p.29, pl.1, figs.4-5.

Glandulina laevigata Cushman and Ozawa, 1930, Proc. U.S. Nat.
 Mus., Vol.77, Art.6, p.143, pl.40, figs.1a,b.

Description :- Test minute, fusiform, pointed at both ends,
 almost circular in transverse section; initial end with
 biserial chambers, later abruptly becoming uniserial; sutures
 distinct; slightly depressed; wall thin, translucent;
 aperture radiate.

The specimen is a megalospheric form.

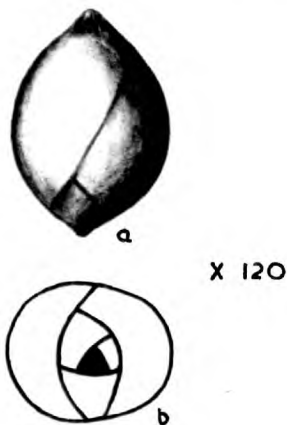
Dimensions :- Length 0.27 mm.; diameter 0.16 mm.

Distribution :- Most of the records refer to forms quite
 different from d'Orbigny's G.laevigata in which the initial
 end is distinctly biserial.

D'Orbigny recorded this species from the Adriatic Sea, the Tertiaries of Sienna, Italy, and the Miocene of the Vienna Basin, Austria. It has also been recorded from the Miocene of Hungary (Karrer, 1863), Oligo-Miocene of Holland (ten Dam, 1938); Oligocene of Germany at the following localities :- Zetzeit (Klahn, 1915), Welbach and Offenbach (Spandel, 1909), Pietzpuhl (Reuss, 1870) and Magdeburg, (Franke, 1925); SubAlpine Molasse of Bavaria (Hagn & Hölzl, 1952); and from the Barton beds, Eocene, of the Hampshire Basin, England. From the present-day seas, Cushman records the species from the Pacific Ocean (1913, -27, -33) and Atlantic Ocean (1923). Earland (1934, -36) and Heron-Allen & Earland (1922) record it from several stations in the Antarctic Ocean. Brady (1884) recorded the species from the Atlantic, Pacific and Southern Oceans, and also from the Red Sea. Wright (1891) records it off the South-West of Ireland.

A single specimen of the species was found in sample W 18, from the Brockenhurst beds, Middle Headon, Whitecliff Bay.

Genus: Globulina d'Orbigny, 1839.



Globulina ampulla (Jones).

Polymorphina ampulla Jones, 1852, Quart. Journ. Geol. Soc. Vol. 8, p. 267, pl. 16, fig. 14.

Polymorphina gibba d'Orbigny var. ampulla Burrows and Holland, 1897, Proc. Geol. Assoc., vol. 15, p. 45, pl. 2, fig. 14.

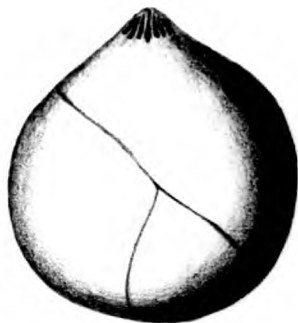
Globulina ampulla (Jones) Cushman and Ozawa, 1930, Proc. U.S. Nat. Mus., vol. 77, Art. 6, p. 79, pl. 19, figs. 9a-c. (et syn), (non vidi Guttulina nitida d'Orbigny, 1826; Fornasini, 1901).

Description :- Test subglobose, almost circular in transverse section, both apertural and initial end pointed; chambers few; sutures depressed, more so near the initial end; wall thin; aperture radiate.

Dimensions :- Length 0.25 mm.; diameter 0.18 mm.

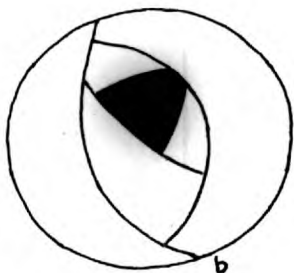
Distribution :- The types of this species were from the Lower Eocene (Thanetian) Thanet sands, Pegwell Bay, England. Other records of this species are from the Eocene of France at Parnes (Les Bôves) and Vaudancourt (fide Cushman & Ozawa, loc.cit.). One specimen referable to this species was found in sample W9 from the Brockenhurst beds, Middle Headon, Whitecliff Bay.

Remarks :- The type specimens of Polymorphina ampulla Jones, 1852, were examined at the British Museum, Natural History (Cat.No.P239). Of the five specimens mounted in the type slide, the one on the extreme left is not a polymorphinid at all, but probably a Rotalia; specimen number 2 (from left) is probably an ostracod. The other three specimens have been damaged and are hardly utilisable. The identification is based on the figures given by Cushman and Ozawa (loc.cit.).



a

X 95



b

Globulina gibba d'Orbigny.

Polymorphina (Globulina) gibba d'Orbigny, 1826, Ann.Sci.Nat.,
vol.7, p.266, No.10, Modèles No.63,

Globulina gibba d'Orbigny, 1846, Foram. Foss. Bass.

Tert.Vienne, p.227, pl.13, figs.13-14.

Polymorphina (Globulina) gibba (d'Orbigny) Egger, 1857, Neues
Jahrb. für.Min., Jahrg, p.239, pl.13, figs.1-4.

Polymorphina gibba (d'Orbigny) Brady, Parker and Jones, 1870,
Trans. Linn. Soc., vol.27, p.216, pl.39, figs. 2a,b.

Gutfulina (Globulina) gibba (d'Orbigny) Cushman, 1928, Bull.
Soc.Sci.Seine-et-oise, sér2, vol.9, p.50, pl.1,
figs.4a-c and 5a,b.

Globulina gibba (d'Orbigny) Cushman and Ozawa, 1930, Proc.
U.S.Nat. Mus., vol.77, Art.6, p.60, pl.16, figs.1-4
(et.syn.).

Description :- Test globular, almost circular in cross section; chambers few, arranged in a triserial series; sutures flush, clear; wall smooth, thick and translucent, aperture radiate.

Dimensions :- Length 0.32 - 0.44 mm.; diameter 0.25 - 0.39 mm.

Distribution :- Globulina gibba is a cosmopolitan species, and has been recorded from all formations ranging from Eocene to Recent. The records from Mesozoic deposits are not correct (fide Cushman and Ozawa, loc.cit.). d'Orbigny first described the species from Recent shore sand at Rimini, Italy and fossil specimens from Castel Arquato, Italy.

Other records of this species are from:-

Eocene of France at Vaudancourt, Chaussy, Parnes (Les Bôves); Bracklesham beds, Whitecliff Bay, Isle of Wight, England; and also Eocene of Belgium, Germany, Italy and Holland; Oligocene of Germany at Ahnatal, near Cassel, Hermsdorf near Berlin, Egisheim, Lattdorf; Miocene of the Vienna Basin, Austria; and also of France, Hungary, Germany and Holland; Pliocene Crag of Sutton, England; Antwerp Crag, Belgium and Castel Arquato, Italy; Recent from Mediterranean and South-west of Ireland.

It is rare to frequent in 4 samples from the Middle Headon beds at Whitecliff Bay (samples W8, W12, W. 15 and W17), the figured specimens being from sample W8.



X 116

Globulina gibba d'Orbigny var. tuberculata (d'Orbigny).

Globulina tuberculata d'Orbigny, 1846, Foram. Foss. Bass.Tert.
Vienne, p.230, pl.13, figs.21,22.

Polymorphina (Globulina) tuberculata (d'Orbigny) Egger, 1857,
Neues Jahrb. für.min., Jahrg, p.292, pl.14, figs.7,8.

Polymorphina tuberculata (d'Orbigny) Brady, Parker and Jones,
1870, Trans.Linn.Soc., vol.27, p.242, pl.41, figs.35a,d.

Globulina gibba d'Orbigny var. tuberculata (d'Orbigny)

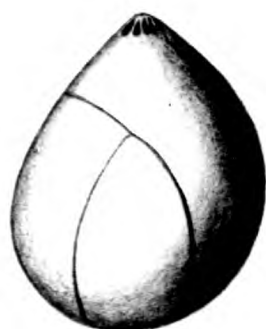
Cushman and Ozawa, 1930, Proc.U.S.Nat. Mus., vol.77,
Art.6, p.68, pl.17, figs.6,7 (et syn).

Description :- The variety differs from the typical form
in having small tubercles scattered irregularly over the
test.

Dimensions:- Length 0.27 mm.; diameter 0.20 mm.

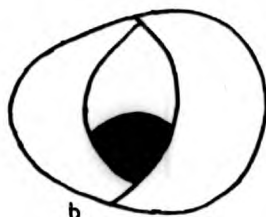
Distribution:- The type specimens of the variety were from the Miocene of Baden, Vienna Basin, Austria. Similar forms are also recorded from the Pliocene Crag of Sutton, England; Castel, Arquato, Italy ; Miocene of Hungary at Kostej, Banat, and of France at Helvetian, Salles, Moulin du Minoy, etc.; Upper Oligocene of Germany at Ahnatal, near Cassel; Eocene of Germany and France.

Only one specimen referable to this species was found in sample W8 from the Middle Headon beds at Whitecliff Bay, and is figured here.



a

X 116



b

Globulina inaequalis Reuss.

Globulina translucida d'Orbigny (nomen nudum), 1826,

Ann.Sci.Nat., vol.7, p.267, No.25.

Globulina inaequalis Reuss, 1850, Denkschr.K.Akad. Wiss.Wien,

vol.1, p.377, pl.48, fig.9.

Globulina inaequalis Cushman and Ozawa, 1930, Proc.U.S.Nat.

Mus., vol.77, Art.6, p.73, pl.18, figs.2-4 (et syn).

Description :- Test oval, tapering towards the apex, somewhat compressed, chambers slightly overlapping; sutures distinct, very slightly depressed; wall smooth, thin; aperture radiate.

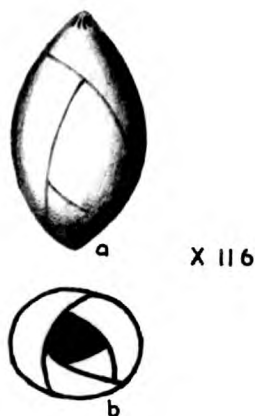
Dimensions :- Length 0.14 - 0.37 mm.; breadth 0.11 - 0.30 mm.; thickness 0.10 - 0.25 mm.

Distribution :- Reuss first described the species from the Miocene of Germany and later recorded it under various names from several Oligocene localities in Germany. Other records are from the following localities:- - Recent shore sand, Rimini, Italy; Pliocene Crag of Sutton, England; Miocene of France (several localities), Vienna Basin, Austria, Hungary, etc., Oligocene of France at Jeurs (Seine et Oise); Eocene of France at Grignon, Chaussy and Damery; Bracklesham beds at Whitecliff Bay, Isle of Wight; Thanet sands of Pegwell Bay, England; and also Eocene of Belgium, Germany and Hungary, etc.

The species was found only in 4 samples from the base of the Middle Headon beds, Whitecliff Bay (sample Nos. W8, W9, W12 and W15). Rare to frequent in occurrence.

Remarks:- Globulina translucida d'Orbigny, 1826, although the older name, was a nomen nudum until figured by Terquem in 1882 and later by Fornasini in 1901, and therefore cannot have priority over Reuss' species.

The species is closely related to G.gibba, but differs from it in the slightly oblong shape and the compressed test.



Globulina sp.cf. minuta (Roemer).

Polymorphina minuta Roemer, 1838, Neues Jahrb. für Min.,
Jahrg, p.386, pl.3, fig.35.

Globulina minuta (Roemer) Cushman and Ozawa, 1930, Proc.
U.S.Nat. Mus., vol.77, Art.6, p.83, pl.20, figs.3,4.

A few specimens from the Middle Headon beds at
Whitecliff Bay (samples W8, W9 and W29) may be questionably
referred to this species.

Dimensions :- Length 0.23 - 0.27 mm.; breadth 0.11 - 0.14 mm.;
thickness 0.09 - 0.11 mm.

Genus: Guttulina d'Orbigny, 1839.



x 92



Guttulina austriaca d'Orbigny.

Guttulina austriaca d'Orbigny, 1846, Foram.Foss.Bass.Tert.

Vienne, p.223, pl.12, figs.23-25.

Guttulina austriaca Cushman and Ozawa, 1930, Proc.U.S.Nat.

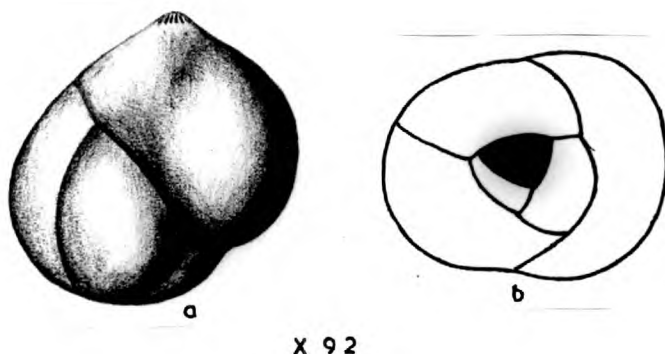
Mus., vol.77, Art.6, p.29, pl.4, figs.3-5 (et.syn.).

Description :- Test elongate, somewhat fusiform, initial end rounded, apertural end pointed; chambers clavate, embracing, each succeeding one much removed from the base; sutures distinct, depressed; wall smooth, very finely perforate; aperture radiate.

Dimensions :- Length 0.51 mm.; diameter 0.20 mm.

Distribution :- The type specimens of the species were from the Miocene of Vienna Basin, Austria. It is also reported from Recent shore sand, Rimini, Italy; Pliocene of Castel Arquato, Italy; and Antwerp Crag, Belgium; Oligocene of Germany at the following localities :- Ahnatal near Cassel, Flonheim, Mainz Basin, Lattorf and Pietzpuhl; Oligo-Miocene of Holland; SubAlpine Molasse of Bavaria; and Eocene of Paris Basin and Belgium.

Only one specimen referable to this species was found in sample HA7, from the Hamstead Corbula beds, Hamstead cliff.



Guttulina bulloides (Reuss).

Globulina bulloides Reuss, 1861(1862), Sitzungsber d.k.

Akad. Wiss. Wien, vol.44, pl.1, p.318, pl.3, fig.4.

Guttulina bulloides Terquem (?) 1878, Mém.Soc.Géol.France,
sér.3, vol.1, p.47, pl.4(9), figs.27a.b; (Reuss)

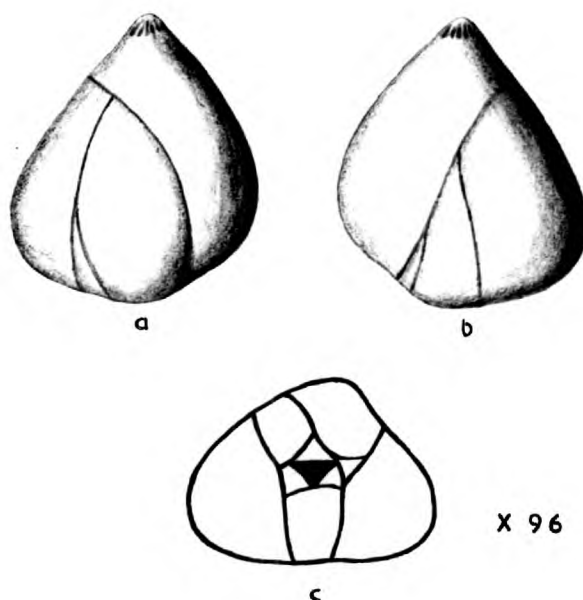
Cushman and Ozawa, 1930, Proc. U.S.Nat.Mus., vol.77,
Art.6, p.23, pl.1, figs.7,8 (et syn.).

Description :- Test subglobular, base broadly rounded,
apertural end less so; chambers inflated, last one rounded
and much removed from the base; sutures depressed distinct;
wall smooth; aperture radiate.

Dimensions :- Length 0.27 - 0.42 mm.; breadth 0.23 - 0.42 mm.;
thickness 0.20 - 0.34 mm.

Distribution :- The species has been reported from the
Miocene beds of several localities in France, Hungary and
Holland, and also the Oligocene of Holland (ten Dam, 1938).
The type specimens, however, were from the Cretaceous of
Maestricht.

Single specimens referable to this species were found in the Middle Headon beds at Whitecliff Bay and Headon Hill (samples W12 and HH8 respectively). The figured specimen is from sample W12.



Guttulina irregularis (d'Orbigny).

Globulina irregularis d'Orbigny, 1846, Foram.Foss.Bass.

Tert. Vienne, p.226, pl.13, figs.9,10.

Guttulina irregularis (d'Orbigny) Cushman and Ozawa, 1930,

Proc.U.S.Nat.Mus., vol.77, Art.6, p.25, pl.3, figs.4,5;

pl.7, figs.1,2. (et syn.).

Description :- Test oval, with somewhat triangular outline, less so in the young forms, triangular in cross section with rounded angles; chambers embracing, very little inflated, each coming down to the base and arranged in a typical 'quinqueloculine' series; sutures slightly depressed; wall smooth and thick; aperture radiate.

Dimensions :- Length 0.23 - 0.48.; breadth 0.18 - 0.45.; thickness 0.14 - 0.38 mm.

Distribution :- The species, like Globulina gibba d'Orbigny has a wide geographical distribution as well as long geological range (Cretaceous to Recent).

Besides the type specimens, which were from the Miocene of Vienna Basin, Austria, identical forms are also recorded from :- Recent and Pliocene of Italy; Miocene of France; Oligocene of Germany at the following localities :- Ahnatal near Cassel, Flonheim, Mainz Basin, Hermsdorf near Berlin, Dusseldorf, Lobsann, Lattdorf, SubAlpine Molasse of Bavaria, etc. ; Eocene of Hungary, Austria, Italy, France, Belgium and Bracklesham Beds, Whitecliff Bay, Isle of Wight, England.

Rare to frequent specimens were found in 3 samples (W8, W9 and W29) from the Middle Headon beds, Whitecliff Bay. The figured specimens are from sample W8.

Genus: Pyrulina d'Orbigny, 1839.



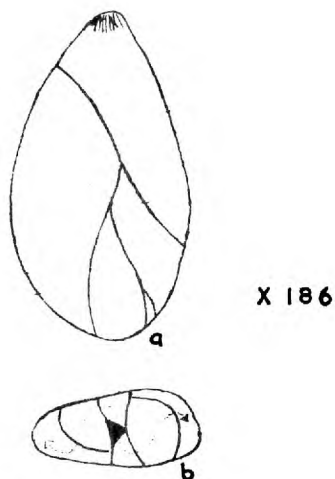
x 114

Pyrulina sp.indet.

The single specimen figured, (the only one found in this material) occurs in sample W28 from the Middle Headon beds at Whitecliff Bay. The sutures are too obscure to be of any help in specific determination.

Dimensions :- Length 0.37 mm.

Genus: Sigmomorphina Cushman and Ozawa, 1928.



Sigmomorphina sp.indet.

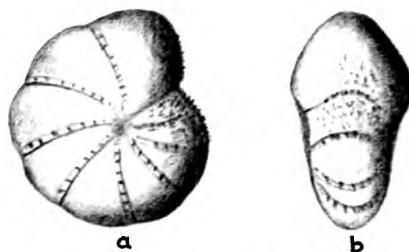
Description :- Test minute, compressed, oval, initial end rounded; chambers elongate, embracing, arranged in a sigmoid series; sutures curved, distinct, slightly depressed; wall thin, smooth; aperture radiate.

Dimensions :- Length 0.23 mm.; breadth 0.13 mm.; thickness 0.09 mm.

Distribution :- Single specimens of this indeterminate species were found in samples W9 and W12 from the Middle Headon beds, Whitecliff Bay.

Family: NONIONIDAE.

Genus: Elphidium Montfort, 1808.



X 100

Elphidium minutum (Reuss).

Polystomella minuta Reuss, 1865, Sitzungsber. d.k.Akad.Wiss.

Wien, vol.50, pt.1, p.478, pl.4, figs.6a,b.

Polystomella discrepans Reuss, ibid., p.478, pl.4, figs.7a,b.

Elphidium minutum (Reuss) Cushman, 1939, U.S.Geol.Surv.,

Prof. Paper 191, p.40, pl.10, figs.22-25.

Elphidium minutum (Reuss) Marks, 1951, Contr. Cushman Found.

Foram. Res., vol.11, pt.2, p.53, pl.6, figs.6a,b.

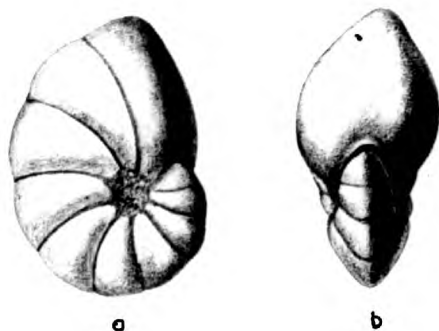
Description :- Test minute, somewhat compressed, periphery broadly rounded, slightly lobulate, umbilici, depressed; chambers 6-9, somewhat inflated; sutures distinct, depressed, gently curved, retral processes small, indistinct; wall finely perforate, smooth, except for very minute spines over the apertural face and a few chambers below it; aperture obscured by the ornamentation, but probably a row of pores at the base of the apertural face.

Dimensions :- Diameter 0.20 - 0.27 mm.; thickness 0.11 - 0.18 mm.

Distribution :- Reuss originally described the species from the Upper Oligocene of Harleshausen, Diekholzen, and Bodenburg, Germany. It has also been recorded from the Upper Oligocene of Doberg, Bünde (Hosius, 1895), Cassel Sands (Reuss, 1865), Germany and the Miocene of the Vienna Basin, Austria (Marks, 1951).

The species is very common in the Middle Headon beds of Colwell Bay and Headon Hill, where it occurs in the majority of the samples. In the Whitecliff Bay section, it was found in three samples from the base of the Brockenhurst beds, Middle Headon. The figured specimens are from sample HH13, Middle Headon beds, Headon Hill.

Genus: Nonion Montfort, 1808.



X 116

Nonion scapha (Fichtel and Moll).

Nautilus scapha Fichtel and Moll, 1798, Test. Micr., p.105,
pl.19, figs.d-f.

Nonionina communis d'Orbigny, 1846, Foram. Foss. Bass. Tert.
Vienne, p.106, pl.5, figs.7,8 (et auctorum).

Nonionina asterisans (F. & M.) var. scapha (F. & M.)

Parker and Jones, 1859, Ann. Mag. Nat. Hist., ser.3,
vol.5, p.5.

Nonionina scapha (F. & M.) Brady, 1865, Nat. Hist. Trans.
Northumberland and Durham, vol.1, p.106, pl.12, figs.
10a,b; 1884, Rept. Voy. Challenger, Zoology, vol.9,
p.730, pl.109, figs.14,15 (non fig.16).

Nonion scaphum (F. & M.) Cushman, 1930, U.S. Nat. Mus.

Bull. 104, pl.7, p.5, pl.2, figs.3,4 ; Marks, 1951,
Contr. Cushman Found. Foramin. Res., vol.11, pl.2, p.49,
pl.5, figs.16a,b (et syn.).

Description :- Test planispiral, bilaterally symmetrical, somewhat compressed, slightly longer than broad, periphery subacute, slightly lobulate; umbilici slightly depressed, usually ornamented with small granules; chambers 10-12, slightly inflated; sutures distinct, depressed, gently curved, slightly limbate near the umbilici, wall smooth, finely perforate; aperture a low opening at the base of the apertural face.

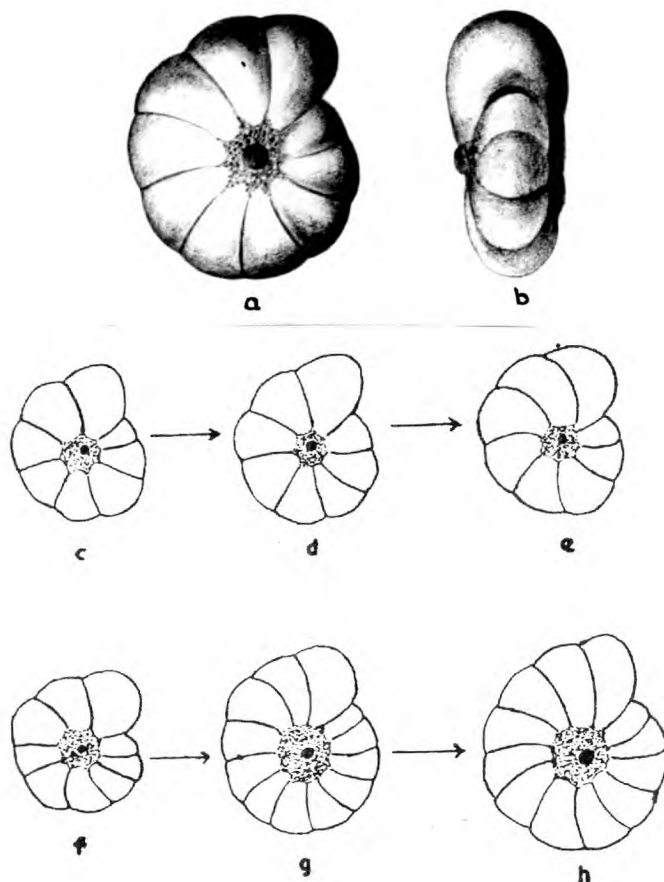
Dimensions:- Length 0.25 - 0.39 mm.; breadth 0.17 - 0.27 mm.; thickness 0.14 - 0.18 mm.

Distribution :- The type specimens of the species were from the Adriatic at Rimini and recorded as fossil in the Sienna region, etc., There are many records of this species, most of which are unaccompanied by figures or descriptions. The range of the species is Eocene to Recent.

Rare to frequent specimens of the species were found in two samples (HA6 and HA7) from the Hamstead Corbula beds, Hamstead Hill. The figured specimens are from sample HA6.

Remarks :- The two species N. scapha and N. commune are here considered to be synonymous (fide Marks, 1951, p.49, et. seq.).

The Isle of Wight specimens are identical with Brady's Challenger specimens (1884), at the British Museum (Natural History).



X 116

Nonion depressulus (Walker and Jacob).

Nautilus spiralis utrinque subumbilicatus Walker
and Boys, 1784, Testacea minuta rariora, p.19, pl.3,
fig.68.

Nautilus depressulus Walker and Jacob, 1798, Adam's Essays,
Kammacher's edn., p.641, pl.14, fig.33.

Nonionina umbilicatula Williamson (non Walker and Jacob), 1858,
Recent Foram. Gt.Britain, p.97, pl.3, figs.70,71.

Nonionina asterisans (Ficht.& Moll) var. depressula (W. & J.)
Parker and Jones, 1859, Ann. Mag. Nat. Hist., ser.3,
vol.4, pp.339, 341.

Polystomella crispa (Linné) var. (Nonionina) depressula (W.&J.)

Parker and Jones, 1865, Philos. Trans., vol.155, p.403,
pl.14, figs.39a,b.

(W.+J.)
Nonionina depressula Brady, 1865, Nat. Hist. Trans.

Northumberland and Durham, vol.1, p.106 ; 1884, Rept.

Voy. Challenger, Zoology vol.9, p.725, pl.109, figs.6,7.

Nonion depressulum (W. &J.) Cushman, 1930, U.S. Nat. Mus.,
Bull.104, pt.7, p.3, pl.1, figs.3-6.

Description :- Test planispiral, compressed, completely involute, periphery lobulate, rounded; umbilici slightly depressed, filled with fine granules in the young forms, in the adult forms often with a small knob in addition; chambers 7-12, inflated; sutures distinct, depressed, curved, slightly limbate near the umbilicus; wall thin, smooth, finely perforate; aperture peripheral, a low arched opening at the base of the apertural face.

The species varies considerably as regards the number of chambers, curvature of sutures, and the amount of umbilical ornamentation. The young forms have 7 or 8 chambers, gently curved sutures, and little umbilical ornamentation (the umbilical knob may sometimes be absent). The adult forms have 11-13 chambers and the sutures are distinctly curved. Usually a distinct umbilical knob is present; the periphery is broadly rounded. All the intermediate stages also occur (see figures c-h).

Dimensions:- Diameter 0.14 - 0.30 mm.; thickness 0.08 - 0.16 mm.

Distribution :- The type specimens of the species were from Reculver, on the north coast of Kent, England.

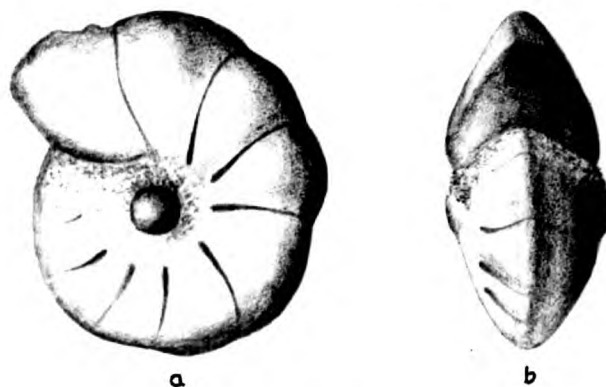
Although the species has a wide geographical distribution in the present-day seas, it is typically developed and abundant around the British Isles. Some of the important records are:- Brady (1865, 1870 & 1887); Balkwill and Wright (1885); Wright (1891); Chaster (1892); and Heron-Allen and Earland (1913, 1916a, 1916b, and 1930). Other Recent records are from the Atlantic and Pacific Oceans (Brady, 1884; Brady, Parker and Jones, 1888; Cushman, 1914, 1930); several localities in the Antarctic Ocean (Earland, 1933, 1934; Heron-Allen and Earland, 1922); off Kerimba Archipelago (Heron-Allen and Earland, 1914,15); off the Belgian coast (Cushman, 1949); West Indian region (Norton, 1930). Hada (1936) records it from the brackish- and normal saline waters in Japan.

In the fossil state, the species has been recorded from the Post - Glacial deposits of England (MacFadyen, several papers); Tertiaries of Cyprus (Ovey, 1937); and Oligocene of Mergel, Germany (Klahn, 1915). It is doubtful whether the numerous other references to this species from the Eocene of France and England are correct. These Eocene species should probably be ascribed to N.graniferum (Terquem),

which has very large beads in the umbilicus and a wide open aperture.

The species occurs in a large majority of samples from the Oligocene materials of the Isle of Wight. It is more abundant in the shallow-water assemblages of the Middle Headon and Bembridge Oyster beds.

Remarks :- Brady's Challenger specimens (1884) at the British Museum (Natural History) are typical of the species, and are identical with the Oligocene specimens from the Isle of Wight.



X 116

Nonion laeve (d'Orbigny) var. minor-excavata,
var. nov.

Diagnosis :- In the variety the sutures are only slightly excavated and do not extend to the umbo, and the surface is occasionally ornamented with small granules of shell material which run from the periphery to the uppermost part of the umbo.

Dimensions :- Diameter 0.20 - 0.41 mm.; thickness 0.12 - 0.19 mm.

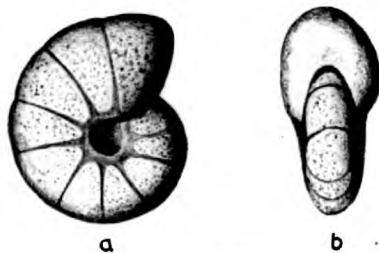
Type material :- Figures (a) and (b) represent the lateral and peripheral aspects respectively of the holotype, from sample W12, Brockenhurst beds, Whitecliff Bay. A total of 14 specimens were collected, distributed among 4 basal samples from the Brockenhurst beds. The diameter of the holotype is 0.41 mm., and thickness 0.19 mm.

Type locality :- Locality No.5, Whitecliff Bay, Isle of Wight. The types were from the Brockenhurst beds — chocolate-brown sandy clay. The associated faunule consists dominantly of Cibicides aknerianus (d'Orbigny), Bitubulo-generina reticulata Cushman, and Quinqueloculina juleana d'Orbigny.

Geologic Age:- Lower Oligocene, Lattorfian.

Discussion :- The variety was compared with the typical specimens of N.laeve from the Eocene of Grignon, Paris Basin. The two are closely allied, except that the Eocene species has very distinct and strongly depressed sutures and prominent umbones. The differences are fairly constant.

Remarks :- The varietal name is derived from the less excavated sutures in specimens from the Isle of Wight.



X 116

Nonion umbilicatus (Walker and Jacob).

Nautilus spiralis umbilicatus geniculis sulcatis Walker and

Boys, 1784, *Testacea minuta rariora*, p.19, pl.3, fig.69.

Nautilus umbilicatus Walker and Jacob, 1798, *Adam's Essays*,

Kanmacher's edn., p.641, pl.14, fig.34.

Nonionina affinis Reuss, 1851, *Deutsch. Geol. Ges., Zeitschr.*,

vol.3, p.72, pl.5, figs.32a,b.(et auctorum).

Truncatulina lobatula (W. & J.) var. umbilicatus (W. & J.)

Parker and Jones, 1859, *Ann. Mag. Nat. Hist.*, ser.3,

vol.4, p.339, 341.

Polystomella crispa (Linné) var. (Nonionina) umbilicatus

Parker and Jones, 1865, *Philos. Trans.*, vol.155, p.405,

pl.14, figs.42a,b ; pl.17, figs.53,59.

Nonionina umbilicatus (Montagu) Brady, 1865, *Nat. Hist. Trans.*

Northumberland and Durham, vol.1, p.106 ; 1884, *Rept.*

Voy. Challenger, *Zoology*, vol.9, p.726, pl.109, figs.8,9,

Nonion umbilicatum (Montagu) Cushman, 1923, *Cush. Lab. Foram.*

Res., *Spec. Publ. No.1*, p.202, pl.27, figs.3a,b.

Nonion? umbilicatum (W. & J.) Cushman, 1930, U.S. Nat.

Mus., Bull. 104, pt.7, p.2, pl.1, figs.1a,b.

Description :- Test planispiral, compressed, periphery rounded, usually entire, very slightly lobulate, if at all, umbilici deeply sunk, with a flush border of clear shell material, unornamented; chambers 8-10, of uniform shape throughout, progressively increasing in size; sutures distinct, flush with the surface, limbate, the broadest part towards the umbilical end, thence thinning towards the periphery, gently curved; wall thin, smooth, rather coarsely perforate; aperture peripheral, a low arched opening below the apertural face.

Dimensions :- Diameter 0.14 - 0.34 mm. thickness 0.08 - 0.18mm.

Distribution :- The type specimens of the species were from Recent shore sand, Sandwich, Kent, England. The species is apparently very common and cosmopolitan in the present-day seas. Some of the important records from around the British Isles are :- Brady (1865,1887); Wright (1891); Chaster (1892); Heron-Allen and Earland (1916a, 1916b, 1930). Brady (1884) recorded the species from several stations in the Atlantic, Pacific and Southern Oceans, the Mediterranean and the Red Sea; Brady, Parker and Jones (1888), from off Abroghlos Bank; Cushman (1914, 1927), from several stations in the Pacific Ocean, and (1930) from the Atlantic Ocean; Earland (1933, 1934) and

Heron-Allen and Earland (1922), from several stations in the Antarctic Ocean; Parker and Jones (1865), from the North Atlantic and Arctic Oceans. Heron-Allen and Earland (1914-15) also record the species from two stations off Kerimba Archipelago, East Africa, while Norton (1930) records it from the West Indian region.

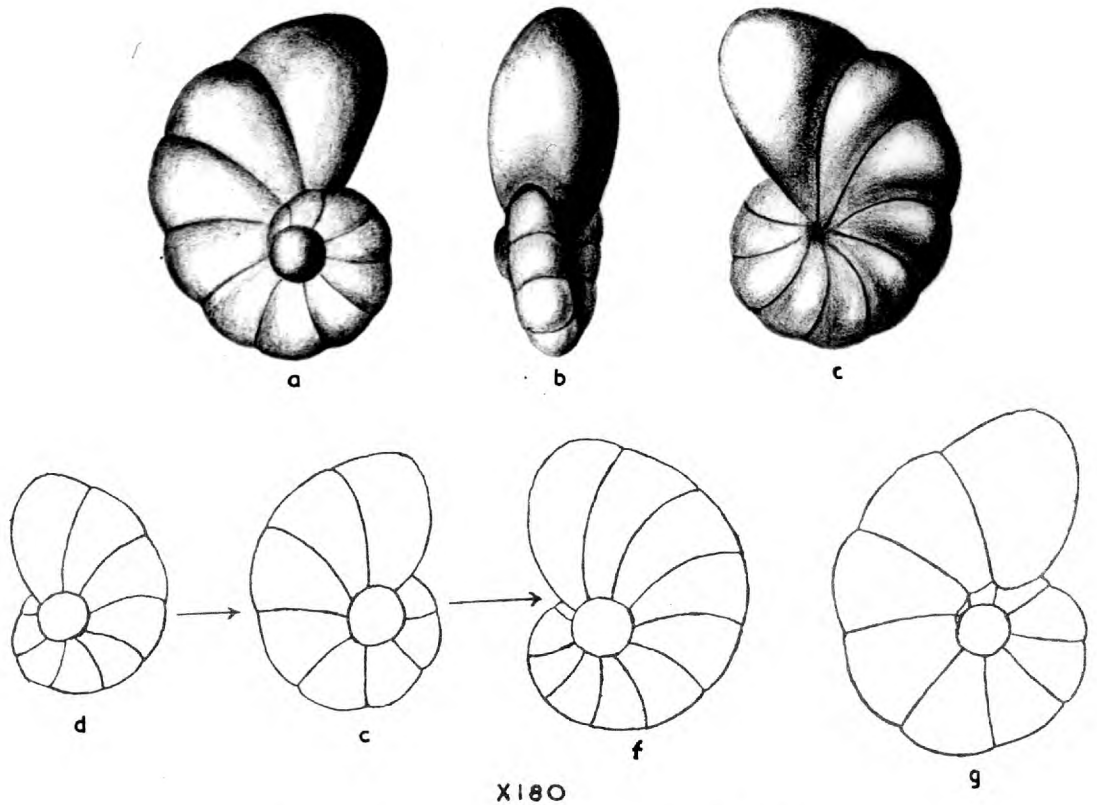
The species is long ranging - Eocene to Recent. Fossil forms have been reported from sub-recent Fen clay of Cambridgeshire and Post-Pliocene of Norway, etc.; Pliocene of the Island of Rhodes (Terquem, 1878); Tertiaries of Cyprus (Ovey, 1937); Oligo-Miocene of Holland (ten Dam, 1938); Oligocene of Germany (Reuss, op.cit.); Oligocene of the Paris Basin (Cushman, 1928); Eocene of Biarritz, France, (Halkyard, 1918); and from several localities in England (various authors).

It is rare to common in 4 samples (W8, W9, W12, and W15) from the Brockenhurst beds, Middle Headon, Whitecliff Bay. The figured specimen is from sample W15.

Remarks:- Brady's Challenger specimens (1884), deposited in the British Museum (Natural History) are fairly typical of the species.

Topotype specimens of N.affinis (Reuss, loc.cit.) from the Middle Oligocene of Hermsdorf, Germany, were examined. These are identical in every respect with the present species.

Genus: Nonionella Cushman, 1926.



Nonionella auricula Heron-Allen and Earland.
Nonionella auricula ^xHeron-Allen and Earland, 1930, Journ.

Roy. Micr. Soc., ser.3, vol.50, Pt.11, p.192, pl.5,
 figs.68-70.

Nonionella auricula Heron-Allen and Earland: Cushman, 1939,
 U.S. Geol. Surv., Prof. Paper 191, p.33, pl.9, figs.7-9;
 1944, Cush. Lab. Foram. Res., Spec. Publ.No.12, p.25,
 pl.3, figs.26,27.

Description :- Test minute, compressed, periphery rounded,
 dorsally slightly evolute, with a prominent umbo in the
 centre; ventral side completely involute, umbilicate;
 chambers distinct, 8-12, fairly rapidly increasing in size

as added; sutures distinct, depressed, slightly curved; wall smooth, finely perforate; aperture a low arched opening, at the base of the apertural face, slightly towards the ventral side.

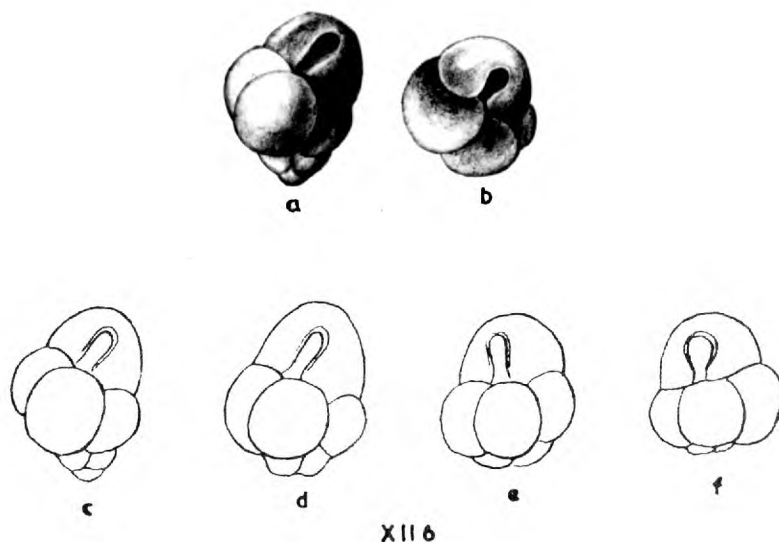
Dimensions :- Length 0.14 - 0.25 mm.; breadth 0.11 - 0.18 mm.; thickness 0.07 - 0.11 mm.

Distribution :- The type specimens of the species were from Station 4, off Plymouth, Devonshire, England. Cushman (1944) records it from several shallow-water stations off the New England coast - Vineyard sound, Buzzards Bay, and Bathing Beach. It has not previously been reported in the fossil state.

It was found only in the Hamstead Corbula beds, Hamstead Hill, and is common in 3 samples (HA6, HA7, and HA9).

Remarks:- The specimens were compared and found to be identical with the type specimens in the British Museum (Natural History).

Family: BULIMINIDAE
 Subfamily: Turriliniinae
 Genus: Buliminella Cushman, 1911.



Buliminella carteri, sp.nov.

?Buliminella sp. Cushman and Renz, 1947, Cush.Lab.

Foram. Res., Spec. Publ. No.22, p.23, pl.6, fig.1.

Diagnosis:- Test small, globose, initial end rounded; chambers distinct, somewhat inflated, 4 to 5 in the last whorl which forms more than two thirds of the test; sutures distinct, depressed; wall smooth, finely perforate; aperture fairly large, comma shaped, with a slight lip. The species shows all gradations (see figures a to f) from stout varieties (with broadly rounded initial ends) to slightly elongate forms (with subacute initial ends).

Dimensions:- Length 0.11 - 0.20 mm.; diameter 0.09 - 0.19 mm.

Type material :- The holotype (figs.a,b) measures 0.20mm. in length, and 0.16 mm. in diameter; from sample HA7, Hamstead Corbula beds, Hamstead Hill.

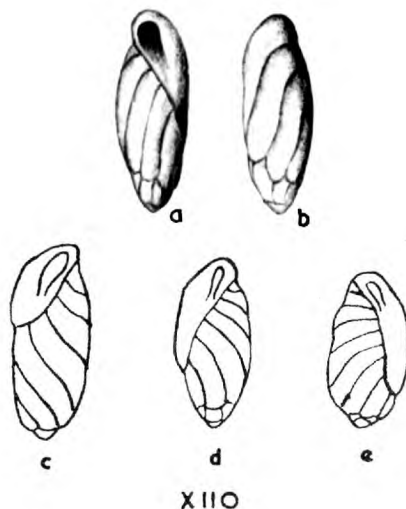
Besides the type horizon, the species also occurs in the Bembridge Oyster and Middle Headon beds. Over 80 specimens were collected from several samples, distributed among the above mentioned beds.

Type locality :- Locality No.3, Hamstead Hill, Isle of Wight, England (see Plate VII). The type specimens were from the Hamstead Corbula beds, forming the uppermost 20ft. or so of the Hamstead series. The bed is a 8-10 ft.thick, stiff bluish-brown clay in which Corbula subpisum J.Sowerby is abundant. The associated faunule consists dominantly of Bulimina spp., Bolivina fastigia Cushman, B.variabilis (Williamson), Angulogerina tenuistriata (Reuss), Virgulina schreibersiana Czjzek, and Pullenia sp.indet.

Geologic Age:- The type specimens were from Middle Oligocene, Rupelian. The species also occurs in the Lower Oligocene, Lattorfian.

Discussion :- Cushman & Renz (loc.cit) figured a somewhat similar species from the Oligocene of Trinidad, British West Indies, but did not assign any name to it. The present species may be identical with the Trinidad species.

Remarks:- The species is named after Mr. D.J. Carter, in recognition of his help and guidance during the preparation of this work.



Buliminella elegantissima (d'Orbigny).

Bulimina elegantissima d'Orbigny, 1839, Voyage dans
l'Amérique Méridionale; Foraminifères, Strasbourg,
vol.5, pt.5, p.51, pl.7, figs.13,14.

Bulimina elegantissima d'Orbigny; Brady, 1884, Rept. Voy.
Challenger, Zoology, vol.9, p.402, pl.50, figs.20,22.

Buliminella elegantissima (d'Orbigny) Cushman, 1911, U.S.Nat.
Mus., Bull.71, pt.2, p.89; Cushman and Parker, 1947,
U.S.Geol.Surv., Prof. Paper 210-D, p.67, pl.17,
figs.10-12 (et syn).

Description :- Test minute, elongate, closely spirally
coiled, somewhat fusiform in shape, initial end acutely
rounded; 2-3 whorls visible, the last one occupying more
than $\frac{3}{4}$ of the test; chambers 7-11 in the final whorl,
elongate along the longer axis of the test, occasionally
slightly twisted; spiral sutures distinct, depressed; wall
smooth, finely perforate; aperture small, an elongate
loop-shaped opening, set in a depression at the top of the

last formed whorl.

Figures a to e show the range of variation.

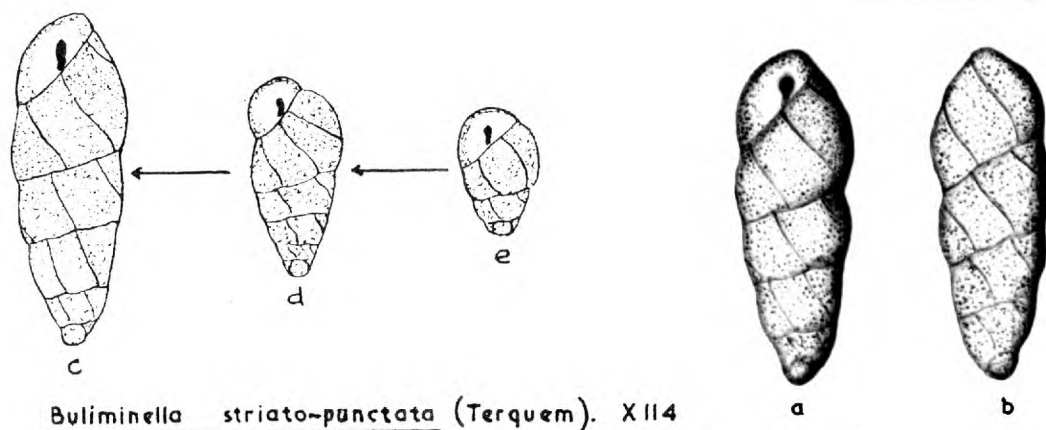
Dimensions:- Length 0.14 - 0.23 mm.; diameter 0.08 - 0.11 mm.

Distribution :- D'Orbigny's type specimens were from several localities off the Western coast of South America. Brady (1884) records it from several stations off the Falkland Islands, South Pacific, and the East coast of Australia. Other Recent records of the species (excluding the British region) are - Cushman (1911), from the Pacific Ocean, and Cushman (1949) off the Belgian coast; Cushman and Parker (1931), from the Atlantic coast of South America; Dawson (1870), from the Gulf of St. Lawrence; Hada (1936), from brackish and normal marine waters of Japan; Heron-Allen and Earland (1922), from the Antarctic Ocean; and Natland (1933), from the Southern Californian region. The records from around the British Isles are - Brady (1865, 1887); Balkwill and Wright (1885); Chaster (1892); Heron-Allen and Earland (1913, 1916a, 1916b); and Wright (1891).

In the fossil state it has been recorded from the Post-Glacial deposits of Cheshire and Lancashire, England (Reade, 1900) ~~MacFadyen, several papers~~ and Norway (Crosskey and Robertson, 1868); Cerithien Sands, Oligocene, of Offenbach, Germany (Paalzo~~w~~, 1924); Bracklesham and Barton beds, Eocene, of the Isle of Wight, England (Brady, 1884);

Eocene Marls of Biarritz, France (Halkyard, 1918). Fossil specimens have also been recorded from shore sand at Selsey Bill (Heron-Allen and Earland, 1909).

A single specimen of this species was found in sample HH13, from the Middle Headon beds, Headon Hill. It becomes common, however, in the Bembridge Oyster beds at Whitecliff Bay, where it was found in the two basal and upper samples. It is rare to common in most of the samples from the Hamstead Corbula beds, Hamstead Cliff. The figured specimens (a) and (b) are from the Bembridge Oyster beds (sample B1). Other specimens are from the Hamstead Corbula beds (sample HA7).



Buliminella striato-punctata (Terquem). X114

Buliminella striato-punctata (Terquem).

Bulimina striato-punctata Terquem, 1882, Mem. Soc. Geol.

France, ser.3, vol.2, p.116, pl.12, fig.19.

Buliminella striato-punctata (Terquem) Le Calvez, 1960, Serv.

Carte Géol. Mém. Paris, III, p.30, pl.2, figs.29,30
(et syn.).

Description :- Test elongate, closely coiled spiral, $2\frac{1}{2}$ -3 times as long as broad, slightly tapering towards the rounded end, apertural end broadly rounded; chambers numerous, 4-6 in the final whorl, very slightly inflated; spiral sutures distinct, slightly depressed; wall smooth, somewhat coarsely perforate, the perforations being usually arranged in parallel lines; aperture small, elongate loop-shaped. Figures c,d, and e, show various growth stages, e representing a young form.

Dimensions :- Length 0.23 - 0.46 mm.; diameter 0.11 - 0.14 mm.

Distribution :- The type specimens of the species were from the Calcaire Grossier of Septeuil, Paris Basin, France.

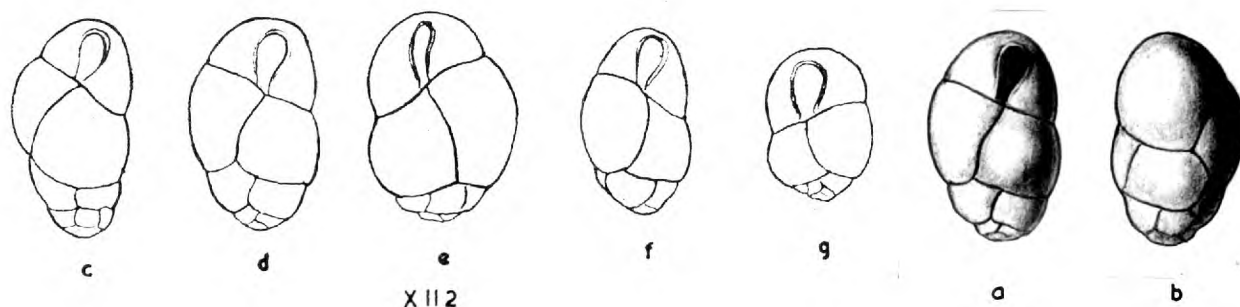
Identical forms have also been recorded from the Middle Eocene at the following localities :- Vaudancourt, Grignon, near Versailles, and Seine et Oise.

The species first appears in the basal part of the Middle Headon beds of Colwell Bay, where it is rare to frequent in 7 samples (C1 - C7). In the basal part of the Bembridge Oyster beds, it is very abundant, but becomes rare towards the top. Of the specimens figured, (a,b) are from the Bembridge Oyster beds and (c to e) from the Middle Headon beds, Colwell Bay.

Remarks :- The species was compared with topotype specimens from the Eocene of the Paris Basin, and found to be identical with them except that the length of the test is slightly less than those from the Paris Basin.

Subfamily: Bulimininae.

Genus: Bulimina d'Orbigny, 1826.



Bulimina coprolithoides Andreae.

Bulimina coprolithoides Andreae, 1884, Abhandl. Geol. Spec.

Karte ElsassLoth., vol.2, pt.3, p.305, pl.6, fig.4a-d;

Cushman and Parker, 1947, U.S.Geol. Surv., Prof. Paper

210-D, p.102, pl.24, figs.9a-c (et syn.).

Description :- Test minute, $1\frac{1}{2}$ - 2 times as long as broad, initial end rounded; chambers few, somewhat inflated, arranged in 2-3 whorls, the last one forming two-thirds of the test; sutures distinct, depressed; wall smooth; finely perforate; aperture rather broad, loop-shaped, with a distinct lip, placed above the junction of the second and third chamber.

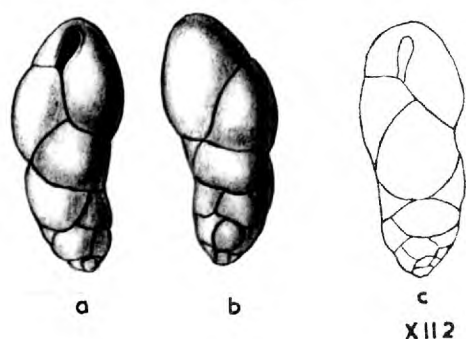
The species shows considerable variation in shape, size and the amount of inflation of the chambers (see figures a to g).

Dimensions:- Length 0.18 - 0.34 mm.; diameter 0.11 - 0.20 mm.

Distribution :- The type specimens were from the Oligocene of Alsace, France. Similar forms have also been recorded from the Oligocene of Ormoy and Dax, Seine-et-Oise (Cushman, 1928); Cerithien sands of Offenbach, Germany (Paalzow, 1924); and Eocene clay of Abbadessa Pass, Bologna, Italy (Selli, 1943).

It is rare to frequent in the majority of the samples from the Middle Headon beds of Colwell Bay and Headon Hill, and in two samples from the Whitecliff Bay section. It is also rare to common in the 2 basal and top samples (B1, B2, B5 and B6), from the Bembridge Oyster beds. It becomes very common in the Hamstead Corbula beds of Hamstead Cliff, where it was found to be present in almost every sample. The figured specimens are from sample HA7, Hamstead Corbula beds, Hamstead Hill.

Remarks :- The species is closely allied to B.pupoides d'Orbigny, from which it is distinguished, however, by the characteristic position of the aperture above the junction of the second and third chamber. The differences are fairly constant.



Bulimina elongata d'Orbigny.

Bulimina elongata d'Orbigny, 1846 (non 1826) Foram. Foss.

Bass. Tert. Vienne, p.187, pl.11, figs.19,20 ;

Cushman and Parker, 1947, U.S. Geol.Surv., Prof.

Paper 210-D, p.108, pl.25, figs.14-17 (et syn.).

Description :- Test elongate. more than three times as long as broad, usually of uniform width throughout, occasionally slightly tapering in the microspheric forms, initial end rather acute; chambers numerous, gradually increasing in size, slightly inflated, arranged in 5-6 whorls; sutures distinct, depressed, wall smooth, finely perforate; aperture elongate, loop-shaped, with a distinct lip. Figures a to c show extent of variation.

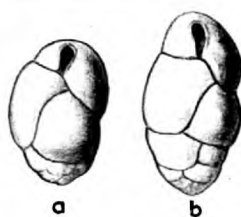
Dimensions :- Length 0.26 - 0.53 mm.; diameter 0.10 - 0.25 mm.

Distribution :- The species is long ranging, occurring from Eocene to Recent. The type specimens were from the Miocene of Nussdorf, Vienna Basin, Austria. Identical forms have also been recorded from the Miocene of several other localities in the Vienna Basin (Marks, 1951). Recent specimens have been reported from the Adriatic sea, Italy. Other records are from the Pliocene Crag of Antwerp, Belgium (Reuss, 1863-~~64~~); Oligocene of Offenbach (Paalzow, 1924) and Gass (Reuss, 1869), Germany; SubAlpine Molasse of Bavaria (Hagn and Hölzl, 1952); Thanet sands of Pegwell Bay (Burrows and Holland, 1897); Eocene of the Paris Basin (Terquem, 1882; Le Calvez, 1950), and Biarritz (Halkyard, 1918). It is doubtful if the Cretaceous records refer to this species.

The Recent records of the species are :- Brady (1884), from several stations in the South Atlantic; Cushman (1911), from the Pacific Ocean and (1922) from the Atlantic Ocean; Earland (1934), from the Weddell sea; and Heron-Allen and Earland (1916a, 1916b, and 1930) from the south coast of England and west coast of Scotland.

In the Isle of Wight material, the species was found in most of the samples from the Hamstead Corbula beds, Hamstead Hill, in which it is frequent to common. The figured specimens are from sample HA7.

Remarks:- Brady's Challenger specimens (1884) were examined at the British Museum (Natural History), and appear to be fairly typical of the species.



X 60

Bulimina pupoides d'Orbigny.

Bulimina pupoides d'Orbigny, 1846, Foram. Foss. Bass. Tert.

Vienne, p.185, pl.11, figs. 11,12 ; Cushman and Parker, 1947, U.S.Geol. Surv., Prof. Paper 210-D, p.105, pl.25, figs.3-7 (et syn.).

Description :- Test minute, about twice as long as broad, initial end subacute to rounded; chambers somewhat inflated, numerous, 4-5 in the elongate ones; sutures distinct, depressed; wall smooth, finely perforate; aperture elongate, loop-shaped with a distinct lip.

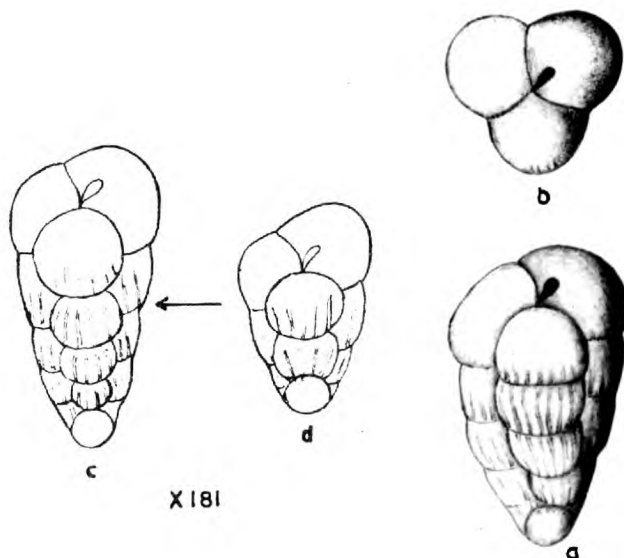
Dimensions :- Length 0.16 - 0.41 mm.; diameter 0.10 - 0.23 mm.

Distribution :- There are numerous records of this cosmopolitan species, which has a long geological range (Eocene to Recent). D'Orbigny's types were from the Miocene of Nussdorf and Baden, in the Vienna Basin, Austria. Recent specimens have been recorded by several authors from around the British Isles (Brady, 1865, 1887; Balkwill and Wright, 1885;

Chaster, 1892; Heron-Allen and Earland, 1916a, 1916b, 1930; and Wright, 1891.)

The species has also been recorded from the Atlantic Ocean (Brady, 1884; Cushman, 1922); off Kerimba Archipelago, East Africa and Antarctic Ocean (Heron-Allen and Earland, 1914-15, 1922). In the fossil state it has been recorded from the following localities:- Late Tertiaries of the neighbourhood of Rome (Terrigi, 1880), Pleistocene and Pliocene of East Anglia, England (Macfayden, 1932), Post glacial deposits of Cheshire and Lancashire (Reade, 1900), Norway, Scotland and Italy, etc., Miocene of Egypt (Macfadyen, 1930), Hungary (Karrer, 1863); Oligocene of Offenbach (Paalzow, 1924) and Septarienthon of Frankfurt, Germany (Andreae, 1894); SubAlpine Molasse, Bavaria (Hagn & Hölzl, 1952); Eocene marls of Biarritz, France (Halkyard, 1918) and several localities in the Paris Basin (Terquem, 1882).

The species is rare in one sample from the Hamstead Corbula beds, and frequent in a few samples from the Bembridge Oyster beds. All the figured specimens are from sample HA7.



Bulimina simplex Cushman and Parker * var. colwelli, var.nov.

Diagnosis :- Test minute, more than twice as long as broad, tapering towards the rounded initial end, proloculum fairly large; chambers numerous, inflated, arranged in a regular triserial series in 4-6 whorls, the last few chambers may be occasionally irregular; sutures distinct, depressed; wall smooth, finely perforate, initial 2/3 of the test very finely costate; aperture very small, usually in the depression at the junction of the last three sutures, somewhat 'comma' shaped.

Dimensions :- Length 0.16 - 0.34 mm.; diameter 0.09 - 0.14 mm.

Type material :- The holotype (figures a,b) measures 0.23 mm. in length, and 0.14 mm. in diameter; from sample CI, Middle Headon beds, Colwell Bay. In all, 18 specimens were collected from seven samples from the Colwell Bay section.

* Terquem's types are not utilisable - fide Le Calvez (1950, p.36).

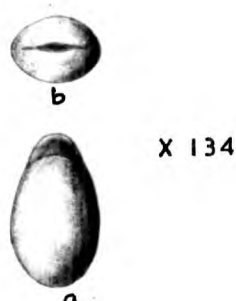
Type locality :- Locality No.2, Colwell Bay, Isle of Wight - about midway between Colwell and Bramble Chine.
The species is restricted to 7 samples from the base of the Middle Headon beds - bluish-green sands and clays - with Theodoxus concavus, Batillaria sp., etc., The associated faunule consists dominantly of Nonion depressulus, Rotalia viennensis and Valvulineria araucana.

Geologic age :- Lower Oligocene, Lattorfian.

Discussion :- The variety differs from the typical form in that the initial end is rounded and the wall is very finely costate in the earlier portion. It is closely allied to Bulimina versa Cushman and Parker, but differs from it in (a) the more regular arrangement of the chambers, (b) the lack of a basal spine, and (c) the finely perforate wall.

Remarks :- The varietal name is derived from the type locality - Colwell Bay - to which the variety is restricted.

Genus: Entosolenia Ehrenberg, 1848.



Entosolenia laevigata (Reuss).

Fissurina laevigata Reuss, 1849, Denkschr. K.Akad. Wiss. Wien,
vol.I, p.366, pl.46, figs.1a,b.

Lagena laevigata (Reuss) Terrigi, 1880, Atti Acad. Pont.

Nuovi Lincei, vol.33, p.177, pl.1, fig.6.

" " (Reuss) Cushman, 1923, U.S.Nat. Mus.,

Bull.104, pt.4, p.28, pl.5, figs.1,2 (et.syn.).

Entosolenia laevigata (Reuss) Cushman, 1944, Cush. Lab. Foram.

Res., Spec. Publ. No.12, p.28, pl.4, fig.12.

Description :- Test minute, single chambered, bilaterally symmetrical, somewhat pyriform in shape, tapering towards the apertural end, base broadly rounded, the two sides convex, periphery subacute; wall smooth, somewhat translucent, finely perforate; apertural end slightly drawn out, acutely rounded, aperture fissurine, terminal, a narrow elongate slit in the median line.

Dimensions:- Length 0.14 - 0.21 mm.; breadth 0.09 - 0.12 mm.
thickness 0.07 - 0.10 mm.

Distribution :- The type specimens of the species were from the Miocene of Grinzing, Germany. Identical forms have also been recorded from the Eocene of Paris Basin (Terquem, 1882; Le Calvez, 1951) and Biarritz (Halkyard, 1918), France; Oligocene of Germany (Reuss, 1870; Spandel, 1909); Miocene of the Vienna Basin, Austria (Czjzek, 1848).

In the present-day seas, the species is common in every part of the world (Brady, 1884). It has been recorded from several localities around the British Isles (Wright, 1885; Brady, 1887; Chaster, 1892; and Heron-Allen and Earland, 1916a, 1916b). Records from the Atlantic Ocean are given by Brady, Parker and Jones (1888), and Cushman (1928, 1944); and from the Pacific Ocean by Cushman (1913). Heron-Allen and Earland (1922) record the species from deep-water stations in the Antarctic Ocean.

Rare to frequent specimens of the species were found in 3 samples from the base of the Brockenhurst beds, Middle Headon, Whitecliff Bay, and in 2 samples from the base of the Hamstead Corbula beds, Hamstead Hill. The figured specimens are from sample HA3, Hamstead Corbula beds.

Subfamily: Virgulininae.

Genus: Bitubulogenerina Howe, 1934.



X 114

Bitubulogenerina reticulata Cushman.

Bitubulogenerina reticulata Cushman, 1936, Cush. Lab. Foram.

Res., Spec. Publ. No.6, p.62, pl.8, figs.21a,b.

Bitubulogenerina reticulata Cushman: Marks, 1951, Contr.Cush.

Found. Foram. Res., vol.1., pt.2, p.61, pl.7, fig.17.

Description :- Test free, somewhat compressed, early portion triserial, sometimes obscured by surface ornamentation or greatly reduced, later portion biserial; chambers somewhat inflated, 4-5 pairs in the biserial portion; sutures almost straight, slightly oblique to the sides; wall finely perforate, covered with thick small protuberances or bumps; aperture somewhat terminal, elongate loop-shaped with a distinct lip.

Dimensions :- Length 0.14 - 0.34 mm.; breadth 0.09 - 0.14 mm; thickness 0.07 - 0.11 mm.

Distribution :- The type specimens of the species were from the Miocene of Kostež, Banat, Hungary. Marks (op.cit.)

records it from the Miocene of the Vienna Basin.

It is rare to common in almost all the samples from the basal Brockenhurst beds, Whitecliff Bay. The figured specimen is from sample W18.

Remarks:- The Isle of Wight specimens were compared with specimens from the Miocene of the Vienna Basin, Austria (kindly lent by Dr. C.W. Drooger, State University, Utrecht, Holland) and found to be identical with them.

Genus: Bolivina d'Orbigny, 1839.



Bolivina beyrichi Reuss var. bituminosa Spandel.

Bolivina beyrichi Reuss var. bituminosa Spandel, 1909,
Offenbach. Ver. Nat. Ber., No.43-50 (1901-1909),
p.207, pl.I, fig.14.

?Bolivina böttgeri Spandel, 1909, ibid., p.207, pl.I, figs.
15a,b.

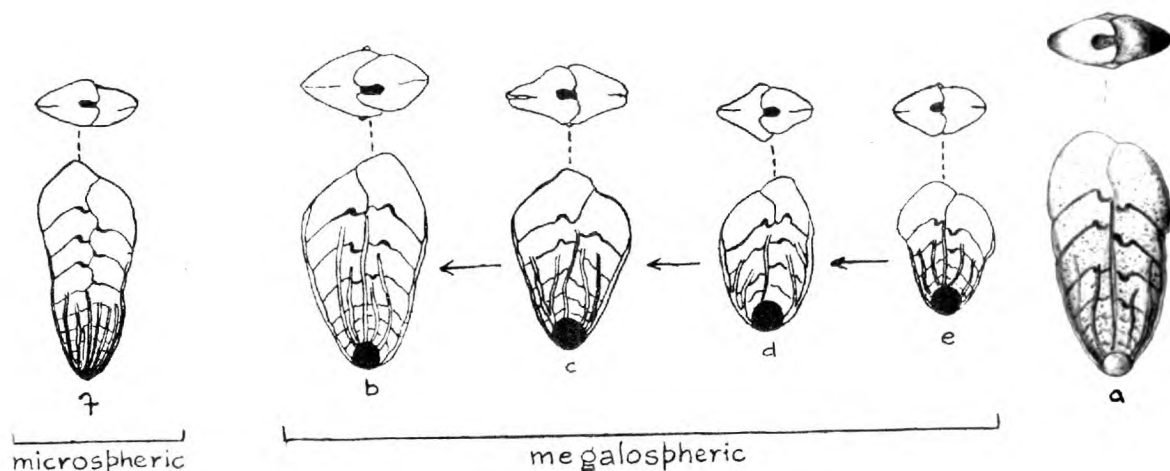
Description :- Test fairly compressed, gradually tapering towards the initial end, which has a prominent and fairly large proloculum, periphery subacute to slightly rounded, somewhat lobulate; chambers numerous, 7-10 pairs, slightly overlapping and inflated, of uniform shape throughout; sutures distinct, depressed, not limbate, strongly curved and oblique; wall smooth, with a shiny surface, somewhat coarsely perforate, aperture a narrow elongate opening, somewhat virguline.

Dimensions :- Length 0.23 - 0.53 mm.; breadth 0.11 - 0.18 mm.; thickness 0.08 - 0.10 mm.

Distribution :- The type specimens of the species were from the Middle Oligocene, Rupelton, of the Mainz Basin, Germany.

In the present material it is frequent to common in the top four samples from the Hamstead Corbula beds, Hamstead Hill. The figured specimen is from sample HA7.

Discussion :- The variety is distinguished from B.beyrichi by the more rounded periphery, the more strongly curved and oblique sutures, and the lack of spiny projections on the margins of the chambers.



Bolivina fastigia Cushman. XII 2

Bolivina fastigia Cushman.

Bolivina fastigia Cushman, 1936, Cush. Lab. Foram. Res.,
 Spec. Publ. No. 6, p. 51, pl. 7, figs. 17a, b; 1937,
 Cush. Lab. Foram. Res., Spec. Publ. No. 9, p. 76,
 pl. 9, figs. 12-14.

Description :- Test minute, $1\frac{1}{2}$ - $2\frac{1}{2}$ times as long as broad, tapering, initial end subacute to rounded, apertural end ovate; periphery rhomboid in end view, acute or subacute, usually with a distinct keel in the earlier portion; chambers distinct, very slightly inflated, if at all, 5-9 pairs, gradually increasing in size with growth; sutures, slightly depressed, limbate, with usually a distinct lobe towards the inner margin, straight or gently curved, forming an angle of 45° with the peripheral margin; wall finely

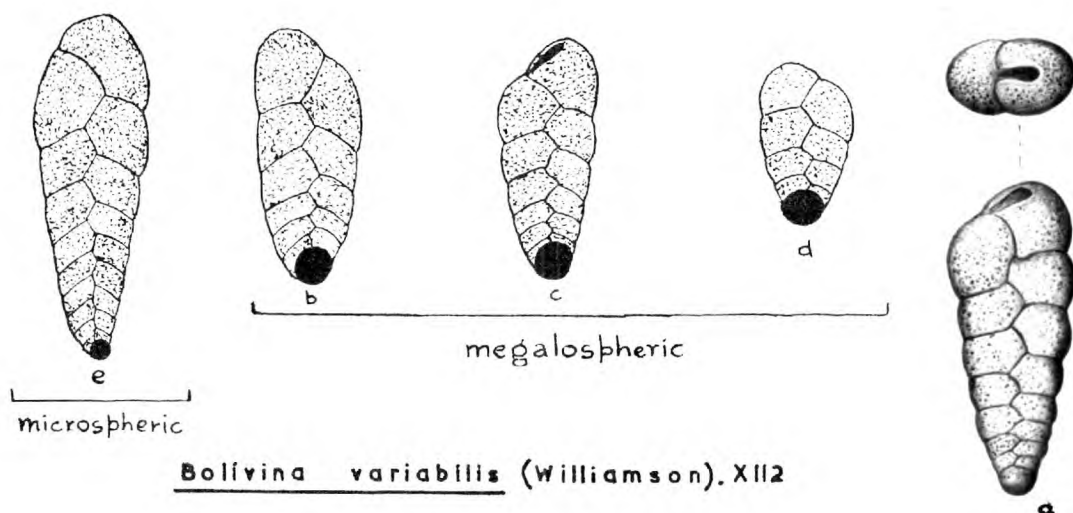
perforate, with usually a distinct median longitudinal ridge and supplementary costae; aperture narrow, an elongate U-shaped opening.

The species occurs in great abundance in the Hamstead Corbula beds, and a large number of specimens were collected to study the range of variation. It is evident from the figures given (a-f) that the species varies considerably, both individually and also within the two dimorphic generations. None of the characters (median carina and sutures with distinct lobes) stated by Cushman to be distinctive of this species, were found to be constant. The most variable characters are the shape of the tests and the number of surface costae. The megalospheric forms (figs. a-e) are $1\frac{1}{2}$ - 2 times as long as broad, tapering, and possessing 8 (or less) pairs of chambers. Surface ornamentation consists usually of a median ridge and 2 or 3 supplementary costae on either side. Usually the periphery is keeled, except in young forms (fig.e) in which it is often subacute. Representative specimens intermediate between the young and adult forms were found (see figs. a-e). The microspheric forms (fig.f) are less tapering with subacute initial end and have 9 or 10 pairs of chambers. The inner lobes may often be absent, and the costae are confined to the initial portion. The median ridge is absent.

Dimensions:- Length up to 0.34 mm.; breadth 0.16 mm.
thickness 0.09 mm.

Distribution :- The type specimens of the species were from the Upper Oligocene of Doberg, near Bünde, Germany. The species has also been recorded from the Miocene of the Vienna Basin (Marks, 1951), and the SubAlpine Molasse (Oligocene) of Bavaria (Hagn & Hölzl, 1952).

The species first appears in the basal Brockenhurst beds, Middle Headon, Whitecliff Bay, where it is rare in 2 samples (W. 8 and W. 12). It becomes very abundant, however, in the Hamstead Corbula beds, occurring in most of the samples.



Bolivina variabilis (Williamson). XII2

Bolivina variabilis (Williamson).

Textularia variabilis Williamson, 1858, Recent Foram. Gt.

Britain, p.76, pl.6, figs.162,163.

Bolivina variabilis (Williamson) Chaster, 1890-1891 (1892),

First Rept., Southport Soc. Nat. Sci., p.59; Cushman,

1937, Cush. Lab. Foram. Res., Spec. Publ. No.9, p.158,

pl.16, figs.6, 12-14 (et syn.).

Description:- Test elongate, compressed, tapering towards the subacute initial end, periphery rounded, lobulate, sometimes less so in the microspheric forms; chambers numerous, 7-10 pairs, distinct, somewhat inflated, with almost parallel sides, depressed, straight or slightly curved; wall smooth, coarsely perforate; aperture large, U-shaped opening.

This is a very variable species (see figures a-e). The

sutures may be straight or gently curved. The ratio of length to breadth varies in microspheric and megalospheric generations. In the former (fig.e), the test is 3 times (or more) as long as broad, with 9-10 pairs of chambers. In the latter (figs, a-d), the test is comparatively stouter ($2-2\frac{1}{2}$ times as long as broad), with 6-8 pairs of chambers. Figure (d) represents a young megalospheric form.

Dimensions :- Length 0.20 - 0.46 mm.; breadth 0.10 - 0.16 mm.; thickness 0.05 - 0.11 mm.

Distribution :- Williamson's type specimens were from several localities off the south coast of England. Other records from around the British Isles are ; Brady (1865); Chaster (1892); Heron-Allen and Earland (1913, 1916a, 1916b, 1930). The species has also been reported from the Atlantic Ocean (Cushman, 1922); from several 'Albatross' stations in the Pacific Ocean (Cushman, 1942); off the New England coast (Cushman, 1944); off the Belgian coast (Cushman, 1949); and off the Kerimba Archipelago (Heron-Allen and Earland, 1914-15).

In the fossil state, the species has been recorded from the Oligocene, Cerithien sands, of Offenbach, Germany (Paalzow, 1924). There are many other records, but in most cases the identifications are erroneous.

The species was found in two samples from the Brockenhurst beds, Whitecliff Bay, where it is rare in

occurrence; it is fairly abundant, however, in the Hamstead Corbula beds, Hamstead Hill, and was found in almost all the samples. All the figured specimens are from sample HA7.

Genus: Virgulina d'Orbigny, 1826.

Virgulina schreibersiana Czjzek.

Virgulina schreibersiana Czjzek, 1847, Haid. Nat. Abh.,

p.147, figs. 13-21; Cushman, 1937, Cush. Lab. Foram.

Res., Spec. Publ. No.9, p.13, pl.2, figs.11-20 (et syn.).

Description :- Test elongate, moderately compressed, greatest width near the apertural end, initial end acute in the adult, somewhat rounded in the young forms; chambers numerous, inflated, elongated, early ones triseriⁱally spiral, later irregularly biserial; sutures distinct, depressed; wall smooth, finely perforate; aperture virguline, a narrow elongate loop-shaped opening at the inner end of the last chamber, with a faint lip. Fairly typical specimens of the species (identical with those from the Miocene of the Vienna Basin) were found in the Hamstead Corbula beds and a large number of individuals were studied. The two dimorphic generations were recognised (see Plate XII, figs.a-f). In the megalospheric forms, the test is $2-2\frac{1}{2}$ times as long as broad, the chambers inflated, elongate, strongly embracing and extending down to the initial portion (at least in the young forms). With growth, however, the succ^eeding chambers are further removed from the base (initial portion). The microspheric forms (fig.f) are large and more elongate (3 times longer than broad).

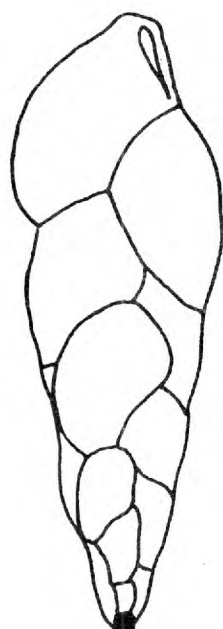
VIRGULINA SCHREIBERSIANA CZJZEK.



e1



e2



f
microspheric



c



b



a

megalospheric

The chambers are numerous, comparatively stout, and less embracing, each succeeding one further removed from the initial portion.

Figures a to e show the various growth stages in the megalospheric generation.

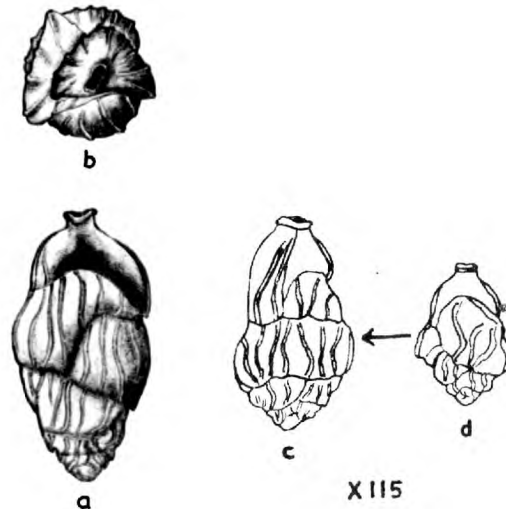
Dimensions :- Length 0.30 - 0.74 mm.; breadth 0.14 - 0.25 mm.; thickness 0.09 - 0.18 mm.

Distribution :- There are numerous records of this species, most of which are evidently not the same as Czjzek's. It is widely distributed and ranges from Oligocene to Recent. The type specimens were from the Miocene of Baden, Vienna Basin, Austria. Identical forms have also been recorded from the following localities :- Upper Oligocene, Ahnatal, near Cassel, SubAlpine Molasse (Oligocene) of Bavaria; Miocene of Banat, Hungary, and of Egypt; Pliocene of Italy; and from the Recent seas at several localities in the Mediterranean, the Weddell sea, etc.

The species is rare to common in a few samples from the Hamstead Corbula bed, Hamstead Cliff (Samples HA6, HA7 and HA9).

Subfamily: Uvigerininae.

Genus: Angulogerina Cushman, 1927.



Angulogerina tenuistriata (Reuss).

Uvigerina tenuistriata Reuss, 1870, Sitzungsber. k.Akad. Wiss.

Wein, vol.62, p.485; von Schlicht, 1870, Foram.

Septar. Pietzpuhl, pl.22, figs.34-37.

Angulogerina tenuistriata (Reuss) Cushman and Edwards, 1938,

Contr. Cush. Lab. Foram. Res., vol.14, pl.4, p.84,

pl.15, figs.1-7.

Description :- Test $2-2\frac{1}{2}$ times as long as broad, initial end acute with chambers triserial, later irregularly so, chambers not noticeably triangular in section, later with prominent chambers, distinct sutures, and triangular cross

section, last chamber with inner sides concave; wall ornamented with longitudinal costae, those of each chamber independent of adjacent ones, occasionally bifurcating, the last chamber sometimes smooth; aperture at the end of a short neck, compressed, with a distinct lip.

Figures a, c and d, show the various growth stages (d representing a young form).

Dimensions :- Length 0.18 - 0.34 mm.; breadth 0.10 - 0.16 mm.; thickness 0.10 - 0.16 mm.

Distribution :- The type specimens of the species were from the Middle Oligocene, Septarienthon, of Pietzpuhl, Germany. Identical forms are also reported from the Middle Oligocene at the following localities :- Septarienthon of Hermsdorf near Berlin; Cerithien sands of Offenbach; Rupelton of Ratigen, near Dusseldorf; Hartmansweiler, Alsace; and the SubAlpine Molasse of Bavaria.

There are many other records of this species, ranging from Oligocene to Recent, but they are not quite the same as the one described by Reuss. Most authors seem to have accepted Brady's figures in the Challenger Report (1884), but these represent an entirely different species (see remarks below). In this connection, Cushman and Edwards (op.cit., p.85) state - "Owing to the poor figures given, and to the fact that fig.37 of von Schlicht represents a comparatively

smooth form which is probably U.gracilis Reuss which also occurs at Pietzpuhl, there has been much confusion in regard to this species. In the Challenger Report, Brady assigned some Recent material to this species which was very different, and his figures have been used by later workers to give the characters. As a result, the range of figures assigned to this species is very wide, and almost none of them represents the species developed abundantly at the type locality."

The species is very common in two samples (HA7 and HA9) from the Hamstead Corbula beds, Hamstead Hill. It was not found in any other section.

Discussion :- A large suite of topotype specimens of A.tenuistriata (from the material kindly lent by Dr. Herbert Hagn of the Munich University) was studied. It is evident from the figures given by von Schlicht (op.cit.), Cushman and Edwards (op.cit.), and a study of the topotype material, that the species shows a wide range of variation in shape, size, and ornamentation. In the topotype material, the microspheric and megalospheric generations were distinguished. The former is recognised by elongate tests ($2\frac{1}{2}$ to 3 times as long as broad), acute initial ends, fewer costae (confined to the initial portion), and long necks. The megalospheric forms are stouter with rounded initial ends, showing more costae which run up to the last chamber, and short necks. Figure 6 of Cushman and Edwards (op.cit. pl.15)

represents a megalospheric form, while fig.5 may be microspheric. Figure 7 in the same publication (which is after Spandel), is certainly a microspheric form.

In the Isle of Wight material from the Middle Oligocene (Rupelian), only the megalospheric forms were found.

A.germanica Cushman and Edwards (op.cit., p.85, pl.15, figs.14-16) appears to be closely allied to A.tenuistriata (Reuss), from which it differs (according to the authors) "in the more inflated chambers, the short neck, and the very much broken longitudinal costae in typical specimen."

As has already been stated, the megalospheric forms of A.tenuistriata have somewhat inflated chambers and short necks. In the topotype specimens from Pietzpuhl, a few specimens show broken costae, which are supposed to be a characteristic feature of A.germanica (supra cit.).

Although it was not possible to get topotype specimens of A.germanica, the differences between the two species appear to be so trivial (at least from the figures given by Cushman and Edwards) that it seems hardly worth while to separate them, on the basis of such variable characters as surface ornamentation, shape, etc. However, for the present, the two species are considered to be different.

Remarks:- Brady's Challenger specimens of U.tenuistriata Reuss, were examined at the British Museum (Natural History)

and compared with topotype specimens. Brady's specimens (which belong to the genus Uvigerina) are distinct from them since the chambers are distinctly rounded and inflated throughout with no signs of keels. The neck and aperture are also quite different.



X 115

Angulogerina oligocaenica (Andreae) aff. var.
globosa (Stoltz).

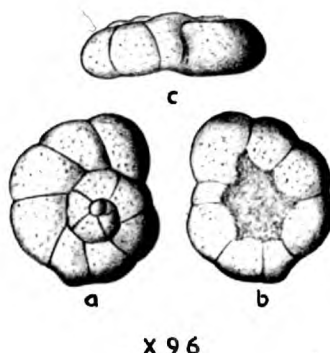
Uvigerina tenuistriata d'Orbigny var. globosa Stoltz, 1925,
Notiz. Ver. fur. Erdkunde, vol. 5, pl. 7, p. 130,
text figure.

Angulogerina oligocaenica (Andreae) var. globosa (Stoltz)
Cushman and Edwards, 1938, Contr. Cushman Lab. Foramin.
Res., vol. 14, pt. 4, p. 86, pl. 15, figs. 12, 13.

The specimen figured above (from sample HA7, Hamstead Corbula
bed) may be questionably referred to this variety. The
test is elongate (3 times as long as broad), the sides are
almost parallel throughout, and the last few chambers are
smooth.

Dimensions :- Length 0.34 mm.; breadth 0.11 mm.

Family: ROTALIIDAE
 Subfamily: Discorbinæ
 Genus: Discorbis Lamarck, 1804.



Discorbis bembridgi, sp.nov.

Diagnosis :- Test minute, compressed trochospiral, periphery rounded, lobulate; dorsal side slightly convex, sometimes flat, with 2-2½ whorls visible; ventral side somewhat concave, with umbilicus usually filled with secondary shell material, running slightly into the sutures; chambers 6-8 in the last whorl, slightly inflated; sutures depressed, almost straight and oblique on the dorsal side, gently curved on the ventral; wall smooth, rather coarsely perforate; aperture indistinct, obscured by the filling on the ventral side.

Dimensions :- Diameter 0.13 - 0.25mm.; thickness 0.10 - 0.14 mm.

Type material :- The holotype (figures a-c) measures 0.23 mm. in diameter, and 0.14 mm. in thickness; from sample B2, Bembridge Oyster beds. In all, 17 specimens were collected.

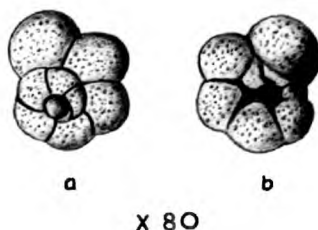
Type locality :- Locality No.4, near Bembridge ledge, Whitecliff Bay, Isle of Wight, England (see Plate VIII).

The type specimens are from the basal part of the Bembridge Oyster beds - whitish-green sands with interstratified clay. The Oyster beds immediately overlies the freshwater compact marls, usually grouped with the underlying Bembridge limestone. At the type locality, the limestone forms the fore-shore. Cyrena semistriata is abundant in the whitish green sands. The associated faunule consists dominantly of Nonion depressulus, and Buliminella stiato-punctata.

Geologic age :- Lower Oligocene, Lattorfian.

Discussion :- The compressed test, straight oblique sutures on the dorsal side and the umbilical filling on the ventral side are distinctive of this species.

Remarks :- The trivial name is derived from the Bembridge Oyster beds, to which the species is restricted.



Discorbis sp.cf. rugosa (d'Orbigny).

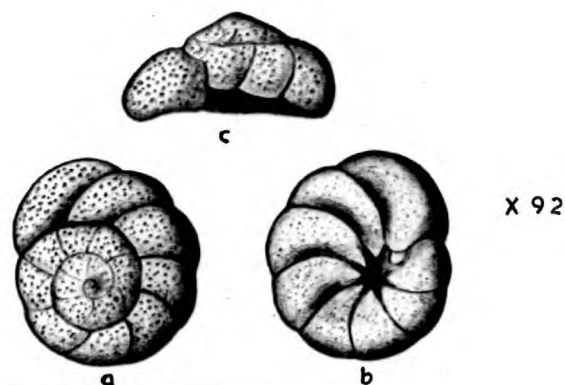
Rosalina rugosa d'Orbigny, 1839, Voyage dans l'Amérique Méridionale; Foraminifères, Strasbourg, vol.5, pt.5, p.42, pl.2, figs.12-14.

Discorbis rugosa (d'Orbigny); Thalmann, 1932, Eclog.geol. Helvt., vol.25, No.2, p.308 (Brady, 1884, p.652, pl.87, fig.3, non pl.91, fig.4).

The specimens figured here may be doubtfully referred to Discorbis rugosa (d'Orbigny). Only 4 specimens were found in sample HH2 from the Middle Headon beds at Headon Hill.

Dimensions :- Diameter 0.24 mm.; thickness 0.10 mm.

Genus: Valvulineria Cushman, 1926.



Valvulineria araucana (d'Orbigny).

Rosalina araucana d'Orbigny, 1839, Voy.Amér. Mérid., vol.5,
pt.5, p.44, pl.6, figs. 16-18.

Discorbina araucana (d'Orbigny) Parker and Jones, 1872, Quart.
Journ. Geol. Soc., vol.28, p.115.

Discorbis araucana (d'Orbigny) Cushman, 1915, U.S. Nat. Mus.
Bull. 71, pt.5, p.15, pl.9, fig.3.

Valvulineria araucana (d'Orbigny) Cushman, 1927, Bull. Scripps
Inst. Oceanography, Tech. Ser., vol.1, No.10, p.160, pl.4,
figs.7,8.

Discorbis araucana (d'Orbigny) Marks, 1951, Contr. Cush.
Found. Foram. Res., vol.11, pt.2, p.63.

Description :- Test trochoid, dorsal side convex, ventral
side flat or concave, umbilicate, periphery slightly
lobulate, acutely rounded; chambers 6-10 in the last whorl,
somewhat inflated, earlier ones often obscured; sutures

depressed, slightly curved, often slightly limbate dorsally; wall thin, coarsely perforate on the dorsal side, smooth and finely perforate on the ventral; aperture ventral, extending from near the periphery to the umbilicus, covered by a flap-like extension of the inner end of the last chamber.

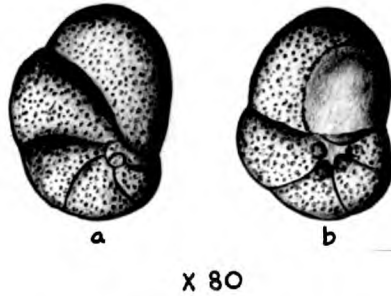
Dimensions :- Diameter 0.14 - 0.34 mm.; thickness 0.07 - 0.18 mm.

Distribution :- d'Orbigny's type specimens were from the Recent sea, off Valparaiso, Chile. According to Brady (1884), it has wide geographical distribution. The species has been recorded from the Atlantic Ocean (Cushman, 1931), off Kerimba Archipelago, East Africa (Heron-Allen and Earland, 1914-15) and from the Southern Californian region (Natland, 1933).

In the fossil state, it has been recorded from the Miocene of the Vienna Basin, Austria (Marks, 1951); Lower Oligocene of the coastal plain (Cushman, 1922); and the Oligocene of Mexico (Nuttall, 1932).

The species is fairly common in the basal and upper samples from the Middle Headon beds at Headon Hill and Colwell Bay, and a single specimen was found in the Whitecliff Bay section (W30). In the Hamstead Corbula beds at Hamstead Hill, it is rare to frequent in the two basal samples (HA1 and HA3). The figured specimens are from sample HH2, Middle Headon beds, Headon Hill.

Remarks:- Brady's Challenger specimens (1884) of Discorbina araucana, were examined at the British Museum (Natural History). Although these specimens are fairly close to d'Orbigny's figures, the sutures are limbate in some specimens and the test not so coarsely perforate (as is evident in d'Orbigny's figures).



Valvulineria subconica (Terquem).

Rotalina subconica Terquem, 1882, Mém. Soc. Géol. France, sér.3, vol.2, p.61, pl.4, figs.5a-c.

Valvulineria subconica (Terquem) Le Calvez, 1949, Serv.

Carte.Géol. Mém., Paris, II, p.26, pl.5, figs.87-89.
(et syn.).

Description :- Test globose, oval, somewhat compressed, periphery lobulate, dorsal side slightly evolute, almost flat; ventral side convex, completely involute with a deep umbilicus; chambers slightly inflated, 5 or 6 in the last whorl, fairly rapidly increasing in size with growth, the last chamber being nearly half the size of the test, inner ends of the earlier chambers on the ventral side have occasionally large knobs; sutures distinct, slightly depressed, curved on the dorsal side, almost straight on the ventral; wall rather coarsely perforate except for a large circular clear area above the aperture on the ventral side; aperture large, extending from the umbilicus to the periphery and covered by a flap-like extension of the inner end of the last chamber.

Dimensions :- Length 0.25 - 0.37 mm.; breadth 0.20 - 0.27 mm.
thickness 0.16 - 0.23 mm.

Distribution :- The type specimens of this species were
from the Middle Eocene of Vaudancourt, Paris Basin.

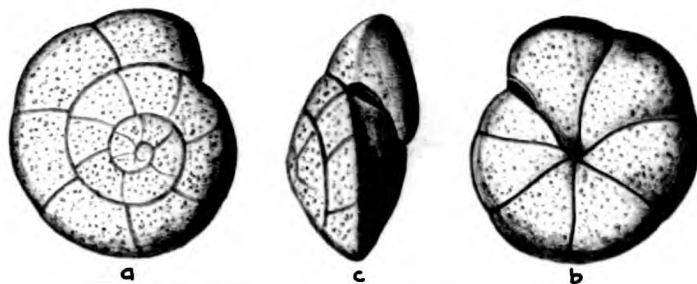
Identical forms have also been reported from the Middle
Eocene at Gueulles-de-Grignon, near Versailles, Septeuil,
and Chaussey II.

The species is rare to frequent in 4 samples from
the Brockenhurst beds, Whitecliff Bay (W8, W15, W16 and W17),
the figured specimens being from sample W15.

Discussion :- The species seems to link the two genera
Baggina and Valvulineria. It possesses the characteristics
of both groups and may well be placed in either. However,
the Isle of Wight specimens were compared with specimens
from Grignon, Paris Basin, and the two are exactly identical,
though in a few specimens from the former material, the
flap is broken or not well developed.

Subfamily: Rotaliinae.

Genus: Eponides Montfort, 1808.



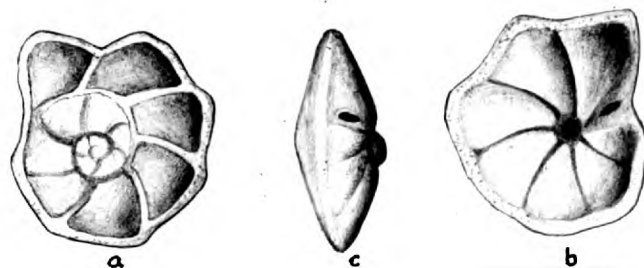
X 120

Eponides sp. cf. pygmeus (Hantken).

Description :- Test minute, rotaliform, almost equally biconvex, periphery slightly lobulate, acute, with a distinct keel; dorsal side with 3 whorls visible in the adult, 7-8 chambers in the final whorl, of uniform shape throughout, sutures distinct, limbate of clear shell material, almost flush with the surface, gently curved; ventral side with close umbilicus, sutures distinct, depressed, slightly limbate near the umbilicus, curved; wall smooth, coarsely perforate; aperture a low opening near the periphery on the ventral side.

Dimensions :- A few specimens, which may be doubtfully referred to E.pygmeus (Hantken), were found in the two basal samples (W8 and W9) from the Brockenhurst beds, Whitecliff Bay. The figured specimens are from sample W9.

Genus: Pararotalia Le Calvez, 1949.



X 30

Pararotalia subinermis, sp.nov.

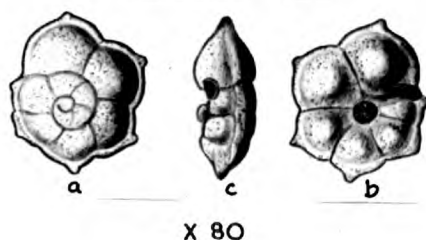
Description :- Test trochoid compressed, usually equally biconvex, but sometimes the dorsal side may be flat; periphery slightly lobulate, young forms occasionally with small spiny projections, subacute, with a keel of fine granular shell material; dorsal side with $2\frac{1}{2}$ whorls visible, 7-9 chambers in the last one; dorsally sutures slightly curved, not depressed, strongly limbate, of clear shell material; ventrally sutures gently curved, strongly depressed, prominent umbo in the centre; wall finely perforate; aperture small, elliptical, midway between periphery and umbo, near the base of the last chamber, with a faint lip.

Type material :- The holotype (fig.a) measures 0.86 mm. in diameter, and 0.34 mm. in thickness; from sample WI6, Brockenhurst beds, Whitecliff Bay. Figures b & c are paratypes. Over 100 specimens were collected, distributed among 4 samples (WI5, WI6, WI7, and WI8) from the Brockenhurst beds.

Type locality :- Locality No.5, Whitecliff Bay, Isle of Wight, England (see Plate VIII). The types were from the Brockenhurst beds - brown sandy clay. The associated faunule consists dominantly of Rotalia canui, Cibicides aknerianus, and Valvulineria subconica.

Discussion :- The species was compared with topotype specimens of P.inermis (Terquem), kindly lent by Mme. Le Calvez, of Rennes University, France. It differs from P.inermis in the more compressed test, strongly limbate dorsal sutures, and the polygonal shape of the chambers.

Genus: Rotalia Lamarck, 1804.



Rotalia canui Cushman.

Rotalia canui Cushman, 1923, Foraminifères du Stampien du Bassin de Paris, Soc. Sci. Seine-et-Oise, Bull., Versailles, sér.2, tome 9, fasc.4, p.55, pl.3, figs.2a-c (et syn.).

Description :- Test minute, rotaloid, almost equally biconvex, periphery lobulate, subacute, with slight traces of a keel, exterior margin of each chamber with a small spiny projection (occasionally the last chamber may be rounded); dorsal side with 5-7 chambers visible in the last whorl, earlier ones often obscure, or ornamented with small beads, sutures distinct, depressed, gently curved, limbate; ventral side with usually a truncate umbo in the centre, sutures strongly depressed, straight, slightly broader towards the centre; wall rather coarsely perforate; aperture an elongate opening at the base of the last chamber, extending from the periphery to the umbilicus with a distinct lip.

Distribution :- Reuss originally described the species from the Oligocene Cassel sands at Luithorst, Germany. Additional records from the Oligocene localities in Germany are from:- ~~G~~lass (Reuss, 1869); and Doberg near Bünde (Hosius, 1895). Cushman (op.cit.) records it from the Oligocene of Ormoy and Dax, France.

A large number of closely allied forms have been described by various authors under different names. It is, therefore, difficult to give an adequate synonymy and an exact distribution, without studying the actual topotype specimens.

The species is restricted to the Brockenhurst beds, Middle Headon, Whitecliff Bay, where it is frequent to abundant in 5 samples (W12, W15, W16, W17 and W18).

Discussion :- As already remarked, the species has probably been recorded under several different names. Some of the closely allied forms are Rotalia armata d'Orb., and Globorotalia spinigera (Terquem) Le Calvez. Some topotype specimens of R.armata were examined. These are comparatively stouter than the present species and have a 'pararotalia' like aperture. Topotype specimens of G.spinigera (kindly lent by Mme.Le Calvez), appear to be closely allied to this species, except that the umbo is absent. As it was not possible to study a large number of individuals of this species, it is difficult to determine its limits of variation. For the present, however, G.spinigera is considered to be a different form.



X 50

Rotalia viennensis (d'Orbigny).

Rosalina viennensis d'Orbigny, 1846, Foram Foss. Bass. Tert.
Vienne, p.177, pl.10, figs. 22-24.

Rotalia viennensis (d'Orbigny) Marks, 1951, Contr. Cush. Found.
~~Lab.~~ Foram. Res., vol.II, p1.2, p.65, pl.8, figs.7a-c
(et syn.).

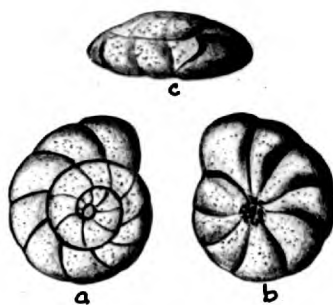
Description :- Test of medium size, trochoid, usually equally biconvex, but occasionally the dorsal side may be more convex, periphery subacutely rounded, with traces of a keel; dorsal side with $2\frac{1}{2}$ -3 whorls visible, 6-8 chambers in the last one, gradually increasing in size with growth, sutures curved, depressed, limbate; ventral side with chambers strongly inflated, not quite touching each other, surrounding a large umbo (occasionally the umbo may be absent), straight or gently curved, strongly depressed; wall thin, smooth, coarsely perforate, somewhat translucent; aperture large, an elongate opening at the base of the apertural face, extending from the periphery to

the umbilicus, with a distinct lip near the periphery.

Dimensions :- Diameter 0.20 - 0.55 mm.; thickness 0.09 - 0.25 mm.

Distribution :- D'Orbigny's type specimens were from the Miocene of the Vienna Basin, Austria. Additional records from the above area are given by Karrer (1863), and Marks (1951). The species also occurs in the Miocene of Ortenburg, Bavaria (Egger, 1857) and in the Oligocene beds near Gran, Hungary (Hantken, 1867).

Excluding Nonion depressulus, this is the most common species in the Middle Headon beds of the Isle of Wight. It is frequent to abundant in the majority of samples from these beds at Colwell Bay, Headon Hill and also from the 'Venus Beds' of the Whitecliff Bay section.



x 80

Rotalia sp.aff. papillosa d'Orbigny (non Brady).

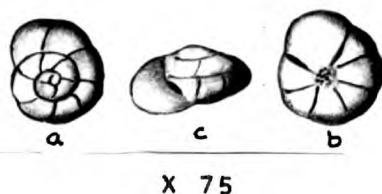
Description :- Test minute, trochoid, dorsal side convex, ventral side less so, or even flat, periphery lobulate, subacute; dorsally 3 whorls visible, of uniform height throughout, 7-10 chambers in the last whorl, very slightly increasing in size with growth; sutures oblique, depressed, somewhat limbate on the dorsal side, curved and slightly excavated on the ventral; umbilical area with small granules or beads; wall thin, rather coarsely perforate, somewhat translucent; aperture ventral, a low opening at the base of the apertural face.

Dimensions :- Diameter 0.16 - 0.27 mm.; thickness 0.08 - 0.11 mm.

Distribution :- In the 'Oligocene' material from the Isle of Wight the species is restricted to the Middle Headon beds. It is rare to common in almost all samples from the Headon Hill and Colwell Bay sections, but occurs

irregularly and less frequently in the Whitecliff Bay section.

Discussion :- This species may be questionably referred to Rotalia papillosa d'Orbigny (non Brady) from the Tertiaries of the Paris Basin. Somewhat similar forms (but with a more conical dorsal side) occur in the Barton beds of the Hampshire Basin, England. The species from the latter locality has probably been recorded as R.trochidiformis (Lamarck). The species from the Barton beds, however, has a minute test which lacks the astral lobes and heavy ornamentation on the ventral side, which are characteristic of Rotalia trochidiformis (Lamarck).



Rotalia sp. indet.

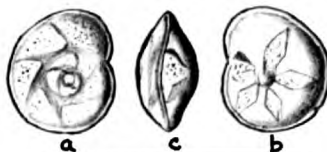
Description :- Test minute, trochoid, periphery rounded, entire, both sides almost equally convex, dorsal side with 2 - 2½ whorls visible; chambers 6-8 in the last whorl; sutures slightly curved, depressed, somewhat limbate on the dorsal side; umbilicus on the ventral side depressed, filled with minute granules; wall finely perforate, smooth; aperture a low opening at the base of the apertural face, between the umbilicus and the periphery.

Dimensions :- Diameter 0.20 mm.; thickness 0.12 mm.

Distribution :- This rather obscure species was found only in the two basal and in two upper samples from the Bembridge Oyster beds, Whitecliff Bay. Rare to common in occurrence. The figured specimens are from sample B2.

Family: AMPHISTEGINIDAE.

Genus: Asterigerina d'Orbigny, 1839.



X 119

Asterigerina sp. indet.

Description :- Test very small, trochoid, almost equally biconvex, periphery acute, with a keel of clear shell material; dorsally about $2\frac{1}{2}$ whorls visible, 5-7 chambers in the last one, rapidly increasing in size, sutures strongly oblique, slightly raised; ventral side with a central umbo of clear shell material, surrounded by 5 or 6 depressions, arranged in a star shaped pattern, extending up to the periphery and sometimes filled with granular material; wall rather coarsely perforate on both sides; aperture rather indistinct, but probably a low arched opening on the ventral side, at the base of the apertural face.

Dimensions :- The maximum diameter is 0.25 mm.; thickness 0.16 mm.

Distribution :- Rare to frequent specimens of the species were found in a few samples from the Brockenhurst beds, Middle Headon, Whitecliff Bay. The specimens are too minute and obscure to allow specific determination.

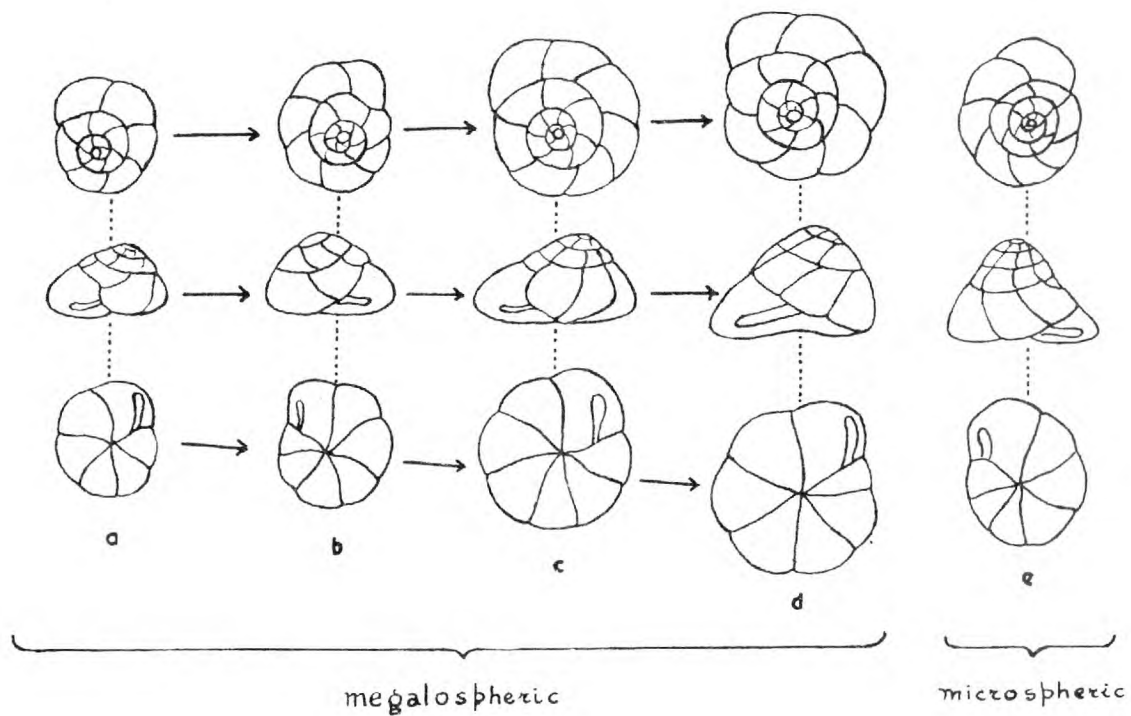
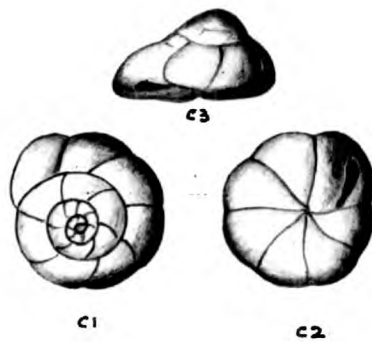
Family: CASSIDULINIDAE.
 Subfamily: Ceratobulimininae.
 Genus: Pseudoparrella Cushman and ten Dam, 1948.

Pseudoparrella oveyi, sp.nov.

Diagnosis :- Test minute, trochoid, dorsal side strongly convex, ventral side flat, umbilicus closed, periphery slightly lobulate, subacutely rounded; dorsally $2\frac{1}{2}$ -4 whorls visible, closely coiled, 6-8 chambers in the last whorl, slightly inflated, gradually increasing in size with growth; sutures slightly depressed, somewhat limbate and oblique on the dorsal side, straight or somewhat sigmoid on the ventral; wall smooth, finely perforate; aperture elongate, ventral, somewhat loop-shaped in the plane of coiling.

A very large number of individuals were examined and the two dimorphic generations were recognised. In the microspheric forms (which are very rare) the test is of medium size, and strongly convex or conical on the dorsal side, on which 4 closely coiled whorls are visible. The megalospheric forms have $2\frac{1}{2}$ - $3\frac{1}{2}$ whorls, which are not so closely coiled as in the microspheric forms. The test is also not so conical. The size of the megalospheric proloculum varies. Figures a-d show growth stages in the megalospheric generation (see Plate XIII).

Dimensions:- The maximum diameter is 0.20 mm. and thickness or height 0.16 mm.



Pseudoparrella oveyi, sp. nov. X122
(showing growth stages).

Type material :- The holotype (figs. ^{C1-C3}~~8-10~~) measures 0.18 mm. in diameter and 0.16 mm. in thickness. In all 41 specimens were found distributed among three samples.

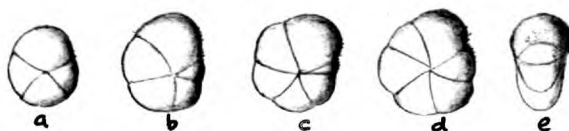
Type locality :- The type locality of the species is the North-east corner of Hamstead Hill (Locality 3, Plate VII), from the Hamstead Corbula beds. The holotype is from sample HA7, a stiff bluish-brown clay in which Corbula subpisum is abundant. The associated faunule consists dominantly of Bulimina spp., Bolivina variabilis (Will), B. fastigia Cushman, Angulogerina tenuistriata (Reuss), etc. The species also occurs in samples HA2 and HA9.

Geologic age :- Middle Oligocene, Rupelian.

Discussion :- The species is easily recognised by its minute size and strongly convex dorsal side on which $2\frac{1}{2}$ to 4 whorls are usually visible.

Remarks:- The species is named after Mr. C.D. Ovey of the British Museum (Natural History). The author has benefited much from his knowledge and deep understanding of the Foraminifera.

Family: Chilostomellidae.
 Subfamily: Allomorphinellinae.
 Genus: Pullenia Parker and Jones, 1862.



X 50

Pullenia sp.indet.

Description :- Test compressed, periphery broadly rounded, lobulate, umbilici depressed; chambers 4-6 (in the early stages 4, increasing to 6 in the adult), slightly inflated, progressively increasing in size; sutures distinct; depressed, straight or gently curved; wall smooth, finely perforate; apertural face rounded, convex, usually covered with minute spines, aperture indistinct, filled with secondary material.

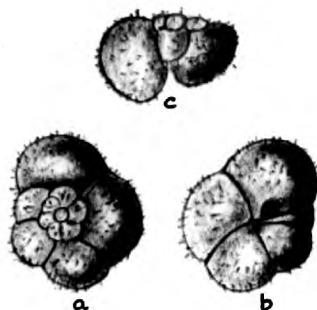
Dimensions :- Diameter 0.14 - 0.30 mm.; thickness 0.09 - 0.16 mm.

Distribution :- The species is frequent to abundant in almost all the samples from the Hamstead Corbula beds. In the Whitecliff Bay section, however, it was found only in 4 samples (W8, W9, W12 and W28) from the Middle Headon beds,

and is comparatively rare in occurrence.

Discussion :- It seems difficult to assign this Pullenia to any of the known species. The number of chambers varies from 4 - 6, and the apertural face together with aperture, is covered with secondary material. In shape, the species seems to be intermediate between P. quinqueloba (Reuss) and P. duplicata Stainforth (= P. compressiuscula auctorum, non Reuss). Abundant topotype specimens of both species were examined. In the Isle of Wight specimens, the periphery is not so subacute as in P. quinqueloba, or so broadly rounded as in P. duplicata. However, the apertural filling seems to be characteristic of this species (except in those specimens in which the last chamber is evidently broken). Cushman and Todd (1943, p.12) note that occasionally in some specimens of P. duplicata (≠ P. compressiuscula) from the Oligocene of Lobsann, the aperture is filled with secondary material. It is therefore probable that the apertural filling is not of any zoological significance, and its presense does not warrant the application of a new name.

Family: Globigerinidae.
Subfamily: Globigerininae.
Genus: Globigerina d'Orbigny, 1826.



X 116

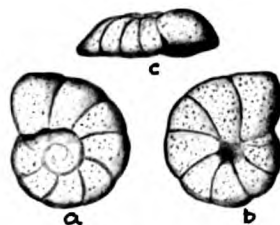
Globigerina sp. indet.

Description :- Test minute, rotaloid, much compressed, periphery lobulate, rounded; dorsal side flattened or slightly curved, with $2\frac{1}{2}$ whorls visible, 5 chambers in the last one, somewhat inflated; ventral side with small hollow umbilicus; surface covered with minute spines; aperture of moderate size, a circular opening, slightly away from the umbilicus.

Dimensions :- The maximum diameter is 0.18 mm., and thickness 0.11 mm.

Distribution :- The species is restricted to the base of the Brockenhurst beds, Middle Headon, Whitecliff Bay, where it is common to abundant in 3 samples (W8, W9 and W12).

Family: ANOMALINIDAE.
 Subfamily: Gibicidinae.
 Genus: Gibicides Montfort, 1808.



X 60

Gibicides aknerianus (d'Orbigny).

Rotalina akneriana d'Orbigny, 1846, Foram. Foss. Bassin. Tert.

Vienne, p.156, pl.8, figs.13-15.

Rotalia akneriana d'Orbigny, 1852, Prodrôme de Paléont., vol.3,

26e Etage B, no.2911.

Truncatulina akneriana Reuss, 1866, Denkschr. d. k. Akad. Wiss

Wien., vol.25, p.160, no.6.

Gibicides akneriana Nuttall, 1932, Journ. Palaeont., vol.6,

No.1, p.32, pl.9, figs.1-3.

Description :- Test plano-convex, dorsal surface flattened, ventral convex, periphery subacute, lobulate; chambers 8-10 in the last whorl, gradually increasing in size; dorsally, earlier whorls are usually visible, but occasionally may be masked by secondary growth of clear shell material, sutures depressed in the last few chambers, but somewhat raised and

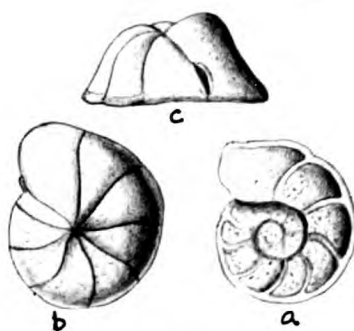
limbate in the earlier ones; ventral surface generally has a broad hollow umbilicus, but occasionally may be filled with clear shell substance, (especially noticeable in young forms), sutures depressed, gently curved; wall smooth, coarsely perforate; aperture an arched opening over the periphery, extending to the dorsal surface along the base of the last few chambers, with a faint lip,

Dimensions :- Diameter 0.16 - 0.39 mm.; thickness 0.09 - 0.20mm.

Distribution:- D'Orbigny's type specimens were from the Miocene of the Vienna Basin, Austria. Recent records by Brady (1884) of this species have been discredited (vide etiam Thalmann, 1932). Identical forms have, however, been recorded from the Miocene and Oligocene of Holland (ten Dam, 1933), and the Oligocene of Germany at the following localities :- Septarienthon of Pietzpuhl (Reuss, 1870), Hermsdorf near Berlin (Bornemanⁿ, 1855), Bünde (Hosius, 1895), etc. ^{Other records of the species are from the Oligocene of Mexico} (Nuttall, 1932); Eocene marls of Biarritz, France (Halkyard, 1918). Derived fossil specimens have been recorded from shore sand at Selsey Bill, England (Heron-Allen and Earland, 1909).

The species was found in the majority of the samples from the Brockenhurst beds, Middle Headon, Whitecliff Bay. It is frequent to abundant in occurrence.

Remarks:- The Isle of Wight specimens are identical with the topotype specimens from the Miocene of the Vienna Basin, Austria.



X 60

Cibicides refulgens Montfort.

Hammonia Balanus seu Balanoidea Soldani, 1789, Testaceographia, vol.I, p.t.I, p.58, pl.46, figs.nn,oo.

Cibicides refulgens Montfort, 1808, Conchyliologie Systématique et classification méthodique de coquilles. Paris, F.Schoell, vol,I, p.123, 31 me.genre.

Truncatulina refulgens (Montfort) d'Orbigny, 1826, Ann.Sci. Nat., vol.7, p.279, pl.13, figs.8-11, modèles, No.77, IVe Livr.; Brady, 1884, Rept. Voy. Challenger Zoology, vol.9, p.659, pl.92, figs.7-9.

Cibicides refulgens (Montfort) Cushman, 1928, Cush.Lab.Foram. Res., Sp.Publ.I, pl.50, figs.2a-c.; 1931, U.S.Nat. Mus., Bull. 104, p.t.3, p.116, pl.21, figs.2a-c.(et syn.).

Description :- Test plano-convex, dorsal surface flattened, ventral highly convex or even conical, periphery slightly lobulate, acute, with a prominent keel; chambers 8-10, fairly gradually increasing in size; dorsally 2 - 2½ whorls

visible, sutures curved, raised and limbate throughout; ventral side with only the last whorl visible, deeply umbilicate, sutures depressed, curved, somewhat sigmoid; wall smooth, finely perforate; aperture peripheral, extending for some distance on to the dorsal surface along the base of the last whorl, with a slight lip.

Dimensions:- Diameter 0.18 - 0.41 mm.; thickness 0.11 - 0.23 mm.

Distribution :- Montfort first described the species from the recent shore sand near Lehorn (Livourne), and in the fossil state from the Tertiaries of Sienna, Italy. The species is very common in present-day seas. Some of the records from around the British Isles are :- Brady (1865,1887); Heron-Allen and Earland (1913,1916a,1916 b, 1930); and Wright (1891). Recent records from other areas are - the Atlantic Ocean (Brady, 1884; Cushman, 1931); the Pacific Ocean (Cushman, 1915); off the Belgian Coast (Cushman,1949); several localities in the Antarctic Ocean (Earland, 1933,1934; Heron-Allen and Earland, 1922); off Kerimba Archipelago (Heron-Allen and Earland, 1914-15); and the West Indian Region (Norton, 1930).

In the fossil state, it has been reported from the post-glacial deposits of North-east Ireland; Glacial clays of Norway; Pliocene Crag of Sutton, England; Eocene Marls of Biarritz, France; Barton beds and London clay, England.

The species is rare to abundant in 3 samples from the Brockenhurst beds, Whitecliff Bay (W8,W9 and W18). Single specimens were also found in 2 samples (HH10 and HH13) from the Middle Heaton beds at Heaton Hill.

VII. FAUNAL DISTRIBUTION.

A. MIDDLE HEADON BEDS.

(a) Whitecliff Bay section.

(i) The Brockenhurst beds :- These beds are 14 ft. thick, and have been divided into a lower 'Brockenhurst zone' (2 ft.) and an upper 'Roydon zone' (12 ft.) (Keeping and Tawney, 1881). As there is no equivalent to these beds in the corresponding sections on the west coast of the island, the characteristic Brockenhurst fauna is absent or represented by a few exotic forms. The foraminifera found in the Brockenhurst beds, are listed in Table 1.

The 'Brockenhurst zone' (samples W8, W9, W10^{4 W11}) is characterised by the abundance of Globigerina sp.indet., and Cibicides aknerianus. Other not so abundant forms are Nonion depressulus, N.umbilicatus, Bitubulogenerina reticulata, and Cibicides refulgens. Though the family Polymorphinidae is represented by a large number of species, the number of individuals is very small.

In the 'Roydon zone' (samples W12 to W13), the Miliolidae (various species) are restricted to two samples - W12 and W15. The upper samples (W15 to W18) are characterised by the dominance of Pararotalia subinermis and Rotalia-canui.

(ii) The 'Barren' sands :- The overlying beds (samples W19 to W27) are bluish-green sands (76 ft), very coarse grained, compact, and with bands of ironstone nodules.

TABLE 1.— DISTRIBUTION OF FORAMINIFERA: MIDDLE HEADON BEDS,
WHITECLIFF BAY.

		BROCKENHURST ZONE				ROYDON ZONE							BARREN SANDS										VENUS BEDS															
SAMPLE NOS. FORAMINIFERAL SPECIES IN %	W	W	W	■	W	●	●	W	W	W	W	●	●	●	●	●	●	▲	▲	W	W	W	W	W	W	W	W	W	W	▲	W	W	W	▲	▲	▲	▲	
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	▲	W	W	W	▲	▲	▲
Clavulina angularis d'Orbigny	0.2								0.2																													
Miliolinella oblonga (Montagu)								2.1																														
Miliolid casts ●																																						
Quinqueloculina bicarinata d'Orbigny								1.5																														
Quinqueloculina impressa var. cognata (B)								2.8																0.8	3.5													
Quinqueloculina pertusa Tarquem								1.3																														
Quinqueloculina juleana d'Orbigny					26.9																																	
Quinqueloculina seminulum (Linnaeus)					0.7			2.6															0.1	15.9	3.5						1.0	19.8						
Quinqueloculina simplex Tarquem								0.1																	7.1								3.1					
Spiroloculina obscura Cushman & Todd								0.5																														
Triloculina trigonula (Lamarck)					3.8			3.3			0.9																											
Glandulina laevigata d'Orbigny											0.9																											
Globulina ampulla (Jonas)		0.7																																				
Globulina gibba d'Orbigny	0.8				0.7			0.1		1.2																												
Globulina gibba var. tuberculata (d'Orb.)	0.2																																					
Globulina inaequalis Reuss	1.9	2.8			0.7			1.1																														
Globulina sp. cf. minuta Roemer	0.4	0.2						0.1														0.8																
Guttulina bulloides (Reuss)					0.3																																	
Guttulina irregularis d'Orbigny	1.0	1.4																				0.2																
Pyrulina sp. indet.																					3.8																	
Sigmomorphina sp. indet.		0.7			0.3																																	
Nonion depressulus (Walker & Jacob)	6.5	4.9	10.0		3.9																13.7	18.0	8.0	82.4	63.9	7.4	12.5	56.7	78.2	100	100		98.0	75.9	100			
Nonion laeve var. minor-excavata var. nov.	0.8	3.9	20.0		1.8																																	
Nonio umbilicatus (Walker & Jacob)	17.0	1.4			1.4			1.1																														
Elphidium minutum (Reuss)	2.7	2.8			3.2																		0.5															
Buliminella carteri sp. nov.																						0.5	88.0					4.3	15.0									
Bulimina coprolithoides Andreae																						0.2											0.1					
Entosolenia laevigata (Reuss)	1.0	4.9			0.7																																	
Bitubulogenerina reticulata Cushman	1.9	4.9	10.0		4.8			0.5		1.2	5.6																											
Bolivina fastigia Cushman	1.2				1.0																																	
Bolivina variabilis (Williamson)	3.2				2.1																																	
Valvulineria araucana (d'Orbigny)																							2.0															
Valvulineria subconica (Terquem)	0.4							1.5	2.5	4.8																												
Eponides sp. cf. pygmaeus (Hantken)	1.9	5.2																																				
Pararotalia subinermis sp. nov.								71.3	69.5	70.7	15.4																											
Rotalia sp. aff. papillosa d'Orbigny	2.9	2.8			1.0			0.8		1.2											31.0	19.5		8.5	10.8			8.6	3.4									
Rotalia canui Cushman					3.2			7.7	15.3	21.9	71.6																											
Rotalia viennensis (d'Orbigny)																					37.9	60.3	2.0	8.5	8.6	78.5	87.5	30.4	3.4			1.0	1.1					
Asterigerina sp. indet.	0.6				1.4			0.1			0.9										6.8	0.5																
Pullenia sp. indet.	0.4	5.2			1.4																6.8																	
Globigerina sp. indet.	27.1	26.3			22.2																																	
Cibicides aknerianus (d'Orbigny)	27.5	29.8	60.0		17.5			1.5	12.5		1.8																											
Cibicides refulgens Montfort	10.6	2.1									2.7																											

■ FORAMINIFERA NOT IDENTIFIABLE.

● ONLY MILIOLID CASTS PRESENT.

▲ FORAMINIFERA ABSENT.

The only foraminifera found in these beds are some obscure pyrite casts of miliolids (see Table 1). The remains are too fragmentary to allow specific identification.

(iii) The 'Venus beds'. :- The foraminifera found in these beds (samples W28 to W42), are generally similar to those of the Middle Headon beds at Headon Hill and Colwell Bay. The dominant species are Nonion depressulus, Rotalia-viennensis, and to a lesser extent, Rotalia sp.aff.papillosa. The miliolids are dominant in 3 samples (W32, W33, and W41), while Buliminella carteri is very abundant in sample W30.

(b) Headon Hill and Colwell Bay sections :- As already remarked, the foraminiferal fauna of the Middle Headon beds at the above localities (see Tables 2 and 3) is essentially the same as that of the 'Venus beds' at Whitecliff Bay. A few species which are not seen in the Whitecliff Bay section appear in the west coast sections, and others which are comparatively rare at the former locality attain dominance. The dominant species found in these beds are Nonion depressulus, Rotalia viennensis, Rotalia sp.aff. papillosa, and Elphidium minutum. The following species do not occur in the Whitecliff Bay section :-

<u>Lagena sulcata</u>	found only in the Headon Hill
	section.
<u>Buliminella elegantissima</u> ..	" " " " "
<u>Discorbus sp.cf.rugosa</u>	" " " " "
<u>Bulimina simplex</u> var. <u>colwelli</u> ..	restricted to Colwell Bay
	section.

TABLE 2.- DISTRIBUTION OF FORAMINIFERA : MIDDLE HEADON BEDS, HEADON HILL.

FORAMINIFERAL SPECIES IN %	SAMPLE NOS.																								
	HH 1	HH 2	▲ HH 3	▲ HH 4	▲ HH 5	HH 6	HH 7	HH 8	HH 9	HH 10	HH 11	HH 12	HH 13	HH 14	HH 15	HH 16	▲ HH 17	HH 18	▲ HH 19	HH 20	▲ HH 21	HH 22	▲ HH 23	HH 24	HH 25
<i>Miliolinella oblonga</i> (Montagu)											1.0							0.7							
<i>Lagena sulcata</i> (Walker & Jacob)											0.2														
<i>Guttulina bulloides</i> (Reuss)								0.2																	
<i>Nonion depressulus</i> (Walker & Jacob)	56.6	0.6				50.6	55.8	56.9	40.5	49.3	30.6	40.8	55.8	44.0	55.0	59.7		86.9		33.4		33.4		98.1	92.4
<i>Elphidium minutum</i> (Reuss)						7.5	8.7	3.5	6.0	5.0	3.6	1.7	7.5	6.6	5.5	1.7									
<i>Buliminella carteri</i> sp. nov.						0.5	0.5	0.7	0.2				0.3			0.5		0.1							
<i>Buliminella elegantissima</i> (d'Orbigny)													0.1												
<i>Bulimina coprolithoides</i> Andreae						2.3	0.5	0.2	0.3	0.3	0.2	0.3	0.5	0.4	0.2	1.7		0.7		33.3				1.6	
<i>Discorbis</i> sp. cf. <i>rugosa</i> (d'Orbigny)		0.5																							
<i>Valvulineria araucana</i> (d'Orbigny)	43.4	98.4																11.5		33.3					
<i>Rotalia</i> sp. aff. <i>papillosa</i> d'Orbigny						13.8	10.3	11.2	10.6	8.5	8.4	16.2	8.2	5.5	16.3	3.0		0.1				33.3		0.3	
<i>Rotalia viennensis</i> (d'Orbigny)		0.5				25.3	24.2	27.3	42.4	36.8	50.0	41.0	27.3	43.5	23.0	33.4						33.3			7.6
<i>Cibicides refulgens</i> Montfort											0.1			0.3											

▲ SAMPLES WITHOUT FORAMINIFERA.

TABLE 3.- DISTRIBUTION OF FORAMINIFERA: MIDDLE HEADON BEDS, COLWELL BAY.

FORAMINIFERAL SPECIES IN %	SAMPLE NOS.																			
	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C 10	C 11	C 12	C 13	C 14	C 15	C 16	C 17	C 18	C 19	C 20
<i>Miliolinella oblonga</i> (Montagu)	0.5	2.9																		
<i>Quinqueloculina seminulum</i> (Linnaeus)		0.9	1.2	8.6	2.8	0.1			0.8											
<i>Quinqueloculina simplex</i> Terquem																11				
<i>Nonion depressulus</i> (Walker & Jacob)	62.2	76.6	30.4	41.8	52.5	32.8	50.8	34.0	22.9	25.6	26.9	25.7	16.5	66.1	96.1	83.5	98.3	100	96.1	99.0
<i>Elphidium minutum</i> (Reuss)				2.1		2.7		5.0	2.0	0.8	0.8	1.4	0.1	1.2		1.6	0.9		3.0	
<i>Buliminella carteri</i> sp. nov.					1.8	4.9	3.0			0.3		0.3	0.1			0.1	0.3			1.0
<i>Buliminella striato-punctata</i> (Terquem)	3.0	1.4	5.4	4.3	3.9	1.1	3.0													
<i>Bulimina coprolithoides</i> Andreae		0.4		2.1					0.2		0.8	0.1	0.2		0.2	0.7	0.3		0.3	
<i>Bulimina simplex</i> var. <i>colwelli</i> var. nov.	3.7	0.9	2.0	4.3	1.9	0.1														
<i>Valvulinaria araucana</i> (d'Orbigny)	10.5	7.0	48.2	8.6	14.2	1.7	12.3	5.0						0.1	0.7	3.7				
<i>Rotalia</i> sp. aff. <i>papillosa</i> d'Orbigny	1.8	0.9		2.1			1.6	1.6	3.5	6.2	5.5	5.1	3.6	10.1	0.2	1.9	0.2		0.6	
<i>Rotalia viennensis</i> (d'Orbigny)	18.3	9.0	12.8	26.1	22.9	56.6	29.3	54.4	70.6	67.1	66.0	67.4	79.5	22.5	2.8	7.4				

Buliminella striato - punctata .. restricted to Colwell Bay section.

From the distribution charts (Tables 2 and 3) it will be noticed that Valvulinergia araucana is restricted in both sections to the basal and upper parts, being entirely absent from the middle portions. Similarly Buliminella striato-punctata and Bulimina simplex var. colwelli are restricted to the basal samples in the Colwell Bay section.

Judd (1880) and others have expressed the opinion that the marine beds of the Headon Hill and Colwell Bay sections are of different ages, the latter being stratigraphically higher than the former. This view was later contradicted and disproved by Keeping and Tawney (1881) and subsequent authors, and their opinions are confirmed by the study of the foraminiferal fauna and the percentage distribution of various species in different samples.

B. BEMBRIDGE OYSTER BEDS.

The fauna of the Bembridge Oyster beds (see Table 4) is essentially similar to that of the Middle Headon beds of Headon Hill and Colwell Bay, with the exception of three species (Discorbis bembridgi sp.nov., Triloculina sp.cf. consorbina, and Rotalia sp.indet.) which appear for the first time, and are restricted to these beds.

TABLE 4.- DISTRIBUTION OF FORAMINIFERA :
BEMBRIDGE OYSTER BEDS, WHITECLIFF BAY.

FORAMINIFERAL SPECIES	SAMPLE NOS.					
	IN %	B 1	B 2	B 3	B 4	B 5
<i>Miliolinella oblonga</i> (Montagu)		12.0	1.5	5.5	44.9	4.4
<i>Triloculina</i> sp. cf. <i>consorbina</i> d'Orb.		2.1	0.2		8.1	
<i>Nonion depressulus</i> (Walker & Jacob)		54.1	86.3	94.5	30.8	72.8
<i>Buliminella carteri</i> sp. nov.						2.9
<i>Buliminella elegantissima</i> (d'Orbigny)		0.9	1.6			1.0
<i>Buliminella striato-punctata</i> (Terquem)		29.0	5.3		8.1	5.2
<i>Bulimina coprolithoides</i> Andreae		0.3	1.0		8.1	1.0
<i>Bulimina pupoides</i> d'Orbigny		0.3	0.1			
<i>Discorbis bembridgi</i> sp. nov.		0.3	1.2			11.5
<i>Rotalia</i> sp. indet.		1.0	2.8			4.1

Nonion depressulus and Miliolinella oblonga are the most abundant species and are present in all the samples. Buliminella elegantissima, which is very rare in the Middle Headon beds at Headon Hill, becomes comparatively abundant in the Bembridge Oyster beds. Buliminella striato-punctata is quite common in the two basal samples, but becomes rare towards the upper part. Discorbis bembridgi is present only in 3 samples, in which it is rare to common.

C. HAMSTEAD CORBULA BEDS.

The Hamstead Corbula beds (about 20ft. thick) contain a fairly rich foraminiferal fauna (Table 5), which is younger than and distinct from that found in the Bembridge Oyster beds and the Middle Headon beds.

The outstanding characteristics of this fauna are :-

- (1) The dominance of the family Buliminidae, which is represented by 12 species and varieties, most of which are distributed throughout the section. The exceptions are Bulimina pupoides, Bolivina beyrichi var. bituminosa, Angulogerina tenuistriata and Virgulina schreibersiana, which are restricted to the upper part only; and Entosolenia laevigata which is confined to the basal samples.
- (2) The Nonionidae and Miliolidae are comparatively less abundant than the Buliminidae. Nonion depressulus is present in most of the samples, but N. scapha and Nonionella auricula are restricted to the upper samples. Quinqueloculina

TABLE 5.— DISTRIBUTION OF FORAMINIFERA : HAMSTEAD CORBULA BEDS, HAMSTEAD HILL.

FORAMINIFERAL SPECIES IN %	SAMPLE NOS.											
	HA 1	HA 2	HA 3	HA 4	HA 5	HA 6	HA 7	▲ HA 8	HA 9	▲ HA 10	▲ HA 11	▲ HA 12
<i>Ammobaculites agglutinans</i> (d'Orbigny)	84.1	63.6			6.5							
<i>Miliolinella oblonga</i> (Montagu)	5.9		4.3		4.3		0.2		0.5			
<i>Quinqueloculina</i> sp. indet.			3.9									
<i>Quinqueloculina seminulum</i> (Linnaeus)		5.1	2.4				0.2					
<i>Quinqueloculina simplex</i> Terquem			1.4									
<i>Guttulina austriaca</i> d'Orbigny							0.1					
<i>Nonion scapha</i> (Fichtel & Moll)						0.6	0.6					
<i>Nonion depressulus</i> (Walker & Jacob)		10.1	27.3			0.3	4.5		10.1			
<i>Nonionella auricula</i> Heron-Allen & Earland						2.1	3.0		9.0			
<i>Buliminella carteri</i> sp. nov.	0.6	1.6		33.3	4.3	12.0	6.3		4.6			
<i>Buliminella elegantissima</i> (d'Orbigny)		0.8	0.3		8.6	0.6	0.9		1.6			
<i>Bulimina coprolithoides</i> Andreae	1.0	10.0	1.2		19.4	18.4	15.2		5.9			
<i>Bulimina elongata</i> d'Orbigny		1.7	0.1		3.0	4.2	1.9		0.8			
<i>Bulimina pupoides</i> d'Orbigny							0.8					
<i>Entosolenia laevigata</i> (Reuss)		0.3	1.2									
<i>Bolivina beyrichi</i> var. <i>bituminosa</i> Spandel					18.2	2.1	1.6		1.0			
<i>Bolivina fastigia</i> Cushman			0.7		8.6	17.6	13.8		38.0			
<i>Bolivina variabilis</i> (Williamson)	5.8	1.6	6.2	33.4	20.2	18.7	14.6		10.9			
<i>Virgulina schreibersiana</i> Czek						0.6	2.3		2.9			
<i>Angulogerina oligocenica</i> var. <i>aff. globosa</i> (Stoltz)							0.1					
<i>Angulogerina tenuistriata</i> (Reuss)							4.4		1.0			
<i>Valvulineria araucana</i> (d'Orbigny)	2.6		1.2									
<i>Pseudoparrella ovayi</i> sp. nov.		3.2					1.0		2.0			
<i>Pullenia</i> sp. indet.		2.0	49.8	33.3	6.9	22.8	35.2		10.6			
(Embryonic Polymorphs)							0.4		0.8			

▲ SAMPLES WITHOUT FORAMINIFERA.

seminulum is somewhat abundant towards the base, but becomes rare towards the top.

(3) The family Chilostomellidae is represented by Pullenia sp.indet., which is very common in almost all the samples.

(4) The Polymorphinidae are represented by a single specimen of Guttulina austriaca, and some embryonic forms of other indeterminate species.

(5) The Rotaliidae are represented by Valvulineria araucana, which is rare. The Cassidulinidae are represented by Pseudoparrella oveyi, which is irregularly distributed.

(6) Ammobaculites agglutinans is very abundant in the basal samples, but becomes less so towards the top.

VIII.

PALAEOECOLOGY.

The late Palaeogene sediments of the Isle of Wight are particularly suitable for depositional and ecological studies. Their lithological associations and contained faunas reflect a varied succession of facies ranging from freshwater through brackish-water to typically marine.

Although the sediments form a well defined and continuously deposited unit, they are divisible into smaller units, each of which is the product of a cycle of sedimentation and its characteristic alternation of depositional environments (vide Stamp, 1921, p.157). Within each sedimentary cycle (e.g. the marine Middle Headon beds), the sediments were deposited in rhythmic pattern with usually an alternation of sands and clays. A major thickness of these beds is of continental origin, and was deposited in freshwater lakes. There are, however, many marine intercalations (often partly brackish) representing marine phases. Only three of these attain any great thickness and contain sufficient number of foraminifera to be of value in systematic and palaeoecological studies. They are, 1) The Middle Headon beds, 2) The Bembridge Oyster beds, and 3) The Hamstead Corbula beds.

It is generally admitted that the deposition of the Middle Headon beds (including the Brockenhurst beds) marked the beginning of a fresh cycle distinct from the Bartonian. During the period of deposition of the Middle Headon beds,

marine conditions returned and the sea spread over a considerable area previously only occupied by freshwater lakes. The marine transgression, which may be attributed to the slight subsidence of the area, came from the east via Belgium and Germany (Stamp, 1950, p.292). This is demonstrated by the facts that the Middle Headon beds attain a greater thickness in the east (Whitecliff Bay area), but gradually thin out towards the west (Colwell Bay and Headon Hill areas); and by the presence of the Oligocene species (in the above mentioned marine beds), which show distinct affinities with those from Belgium and Germany.

Any attempt at a reconstruction of the details of this environmental pattern based on the evidence of foraminifera must, of necessity, be hypothetical, because foraminifera are usually adapted to a wide range of environment in depth, salinity, and to a lesser extent, temperature. Such a reconstruction is, therefore, of little value unless it is substantiated by the occurrence of species of definite ecological value. This work, however, may be further facilitated by the presence of fossil assemblages which change both laterally and vertically. Lateral variations in fossil assemblages often furnish data on the distribution of sedimentary environments or biotopes. Krumbein and Sloss (1951, p.227) define a biotope as "an area inhabited by a uniform community adapted to its environment." On the other hand,

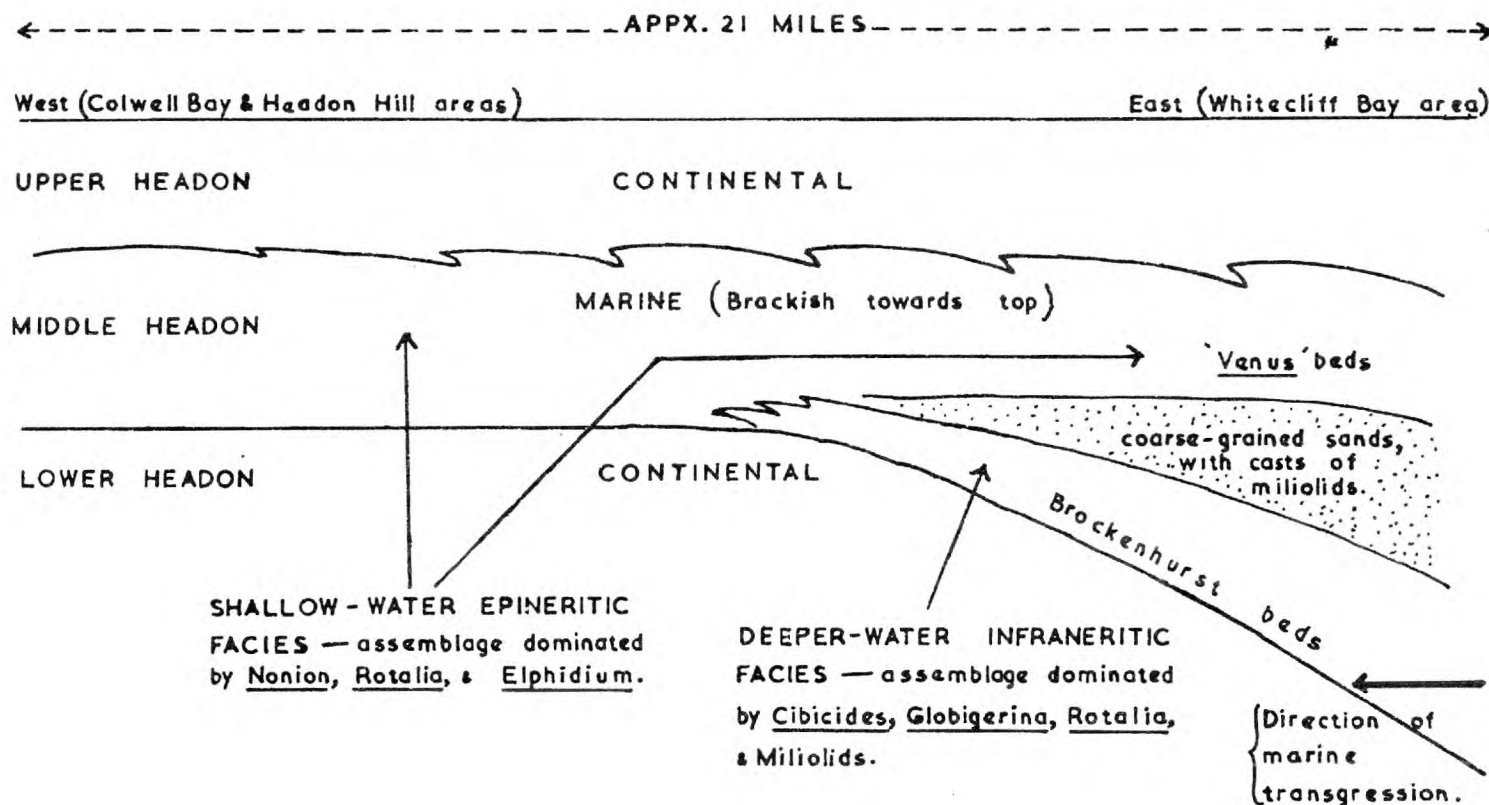
vertical variations in fossil assemblages reflect the continuance or variability of environments through time. It is, therefore, possible to distinguish both lateral and vertical biotopes.

The occurrence of both lateral and vertical biotopes may easily be recognised in the Middle Headon beds of the east and west coast sections of the Isle of Wight. The faunules characterising these biotopes show certain characteristics and peculiarities. These are tabulated in Table 6., (see also Plate XV).

These faunal differences are here attributed to variations in the depth and salinity of the water in which the Middle Headon beds were deposited in the two areas. Whether the depth indirectly affected the temperature is difficult to say from the evidence available. As will be shown later, the foraminiferal evidence suggests that these beds were accumulated in shallow marine waters (neritic environment). The vertical changes in the contained assemblages, coupled with the occurrence of a greater thickness in the Whitecliff Bay area indicate that subsidence took place during the deposition of the Middle Headon sediments. Scott (1940) on the basis of a study of the palaeoecological factors controlling the distribution of Cretaceous Ammonoids in the Texas area, subdivided the neritic type of environment into the epineritic environment, with water depths less than 120 ft. (20 fathoms), and the

TABLE 6. - SHOWING THE CHARACTERISTICS IN THE FORAMINIFERAL
ASSEMBLAGES OF THE MIDDLE HEADON BEDS OF THE EAST AND
WEST COAST SECTIONS

Colwell Bay and Headon Hill sections (west coast).	Whitecliff Bay section (east coast).
<u>'Venus' Beds</u>: - Assemblage dominated by <u>Nonion depressulus</u> (W.&J.), <u>Rotalia viennensis</u> (d'Orb.), <u>Rotalia</u> sp. aff. <u>papillosa</u> d'Orb., and <u>Elphidium minutum</u> (Reuss). <u>Valvulineria araucana</u> (d'Orb.) is restricted in both the sections to the basal and upper parts.	<u>'Venus' Beds</u>: - Assemblage dominated by <u>Nonion depressulus</u> (W.&J.), <u>Rotalia viennensis</u> (d'Orb.), <u>Rotalia</u> sp. aff. <u>papillosa</u> d'Orb., with occasional bands of miliolids.
<u>'Barren' sands</u> are unrepresented in the west coast sections.	<u>'Barren' sands</u>: - Only miliolid casts present.
The characteristic Brockenhurst fauna is absent or represented by a few exotic forms.	<u>Brockenhurst Beds</u>: - Assemblage dominated by <u>Cibicides aknerianus</u> (d'Orb.), <u>G. refu- lgens</u> Montfort, <u>Globigerina</u> sp. indet., <u>Pararotalia subinermis</u> sp. nov., and <u>Rotalia canui</u> Cushman. Occasional bands with miliolids.



HYPOTHETICAL CROSS SECTION OF HEADON CYCLICAL DEPOSITIONAL UNIT, SHOWING THE DISTRIBUTION OF BATHYMETRIC BIOFACIES (DURING MIDDLE HEADON TIMES), AS INTERPRETED FROM FORAMINIFERAL DATA (Vertical scale exaggerated).

Ecological Data of Certain Recent Foraminifera found in the Oligocene of the Isle of Wight.

-Table 7.

	BALKWILL & WRIGHT - 1885	BRADY - 1865	1870	1884	1887	BRADY, PARKER & JONES - 1888	CHASTER - 1892	CUSHMAN - 1918-1931	1927	1932,-33,-42	1944	1949	CUSHMAN & PARKER - 1931	DAWSON - 1870	EARLAND - 1933	1934	HADA - 1936	HERON-ALLEN & EARLAND - 1914-15	1916a	1916b	1922	NATLAND- 1933	NORTON- 1930	WRIGHT - 1891
<i>Ammobaculites agglutinans</i> (d'Orbigny)	VR <50 fms.	-	-	2-3125 fms. C in deep water	0-50 fms.	-	R at 23 fms.	553 fms. (av.)	-	-	-	-	-	-	703 fms. (av.)	>310 fms.	brackish-water, salinity 12.0-33.5 ‰	5-8 fms.	-	-	>1000 fms.	-	-	-
<i>Miliolinella oblonga</i> (Montagu)	R <50 fms.	C, ndg.	moderately common in brackish-waters	all depths	GD, ndg.	31-940 fms.	R 14-23 fms.	ndg.	-	C at 3-80 fms. 189-1385 fms.	-	<28 fms.	-	-	173 fms. (av.)	<122 fms.	-	6-85 fms.	35-40 fms.	30 fms.	129 fms. (av.)	A 2-3-20-8 fms.	all depths	-
<i>Quinqueloculina seminulum</i> (Linnaeus)	A <50 fms.	C, ndg.	F in brackish-waters	0-3000 fms.	GD, ndg.	31-940 fms.	C <23 fms.	F in shallow waters	-	-	ndg.	<28 fms.	-	C 10-16 fms. R 200,3132 fms.	95 fms. (av.)	80-540 fms.	brackish & marine	5-20 fms.	-	A 3-5 fms.	179 fms. (av.)	A <150 fms.	deeper water	F at 7 fms. R at 53 fms.
<i>Triloculina trigonula</i> (Lamarck)	R <50 fms.	A, ndg.	R, sometimes well grown in brackish-waters	C <100 fms.	GD, ndg.	-	F at 23 fms.	ndg.	-	12 fms.	VR 239 fms.	<28 fms.	-	-	-	-	-	5-85 fms.	shore sand	A 10-30 fms.	224 fms. (av.)	A 20-8-150 fms.	warm shallow water	-
<i>Nonion depressulus</i> (Walker & Jacob)	A <50 fms.	C in brackish-waters	A in brackish-waters	C <50 fms. & brackish-waters	C in brackish-waters	R 260 fms.	C <23 fms.	ndg.	-	-	-	A <28 fms.	-	-	102 fms. (av.)	A <150 fms.	brackish & marine	A <22 fms.	GD in shallow water	A at 18 fms.	118 fms. (av.)	-	wide depth range	C at 7 fms. R at 345 fms.
<i>Nonion scapha</i> (Fichtel & Moll)	VR <50 fms.	R 40-48 fms.	-	0-1375 fms.	C 40-120 fms.	40-260 fms.	R at 23 fms.	ndg.	-	-	-	R <28 fms.	-	C in shallow waters	116 fms. (av.)	R, ndg.	-	ndg.	-	VR, ndg.	-	A 2-3-20-8 fms.	<60 fms.	VR at 345, 750 fms.
<i>Nonion umbilicatus</i> (Walker & Jacob)	-	R 40-48 fms.	-	30-3125 fms.	C in deeper water	31-940 fms.	VR <23 fms.	ndg.	321 fms. (av.)	-	-	-	-	-	623 fms. (av.)	207 fms. (av.)	-	R at 6 fms.	-	ndg.	361 fms. (av.)	A >1000 fms.	wide depth range	C 53-750 fms.
<i>Nonionella auricula</i> Heron-Allen & Earland	-	-	-	-	-	-	-	-	-	-	C 6-13 fms.	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Buliminella elegantissima</i> (d'Orbigny)	R <50 fms.	VR, ndg.	R in brackish-waters	2-610 fms.	R, ndg.	-	F <23 fms.	-	-	-	6 fms.	C <28 fms.	VA <15 fms.	C 18-20 fms.	53 fms.	-	brackish & marine	C, exposed coral reefs.	35-40 fms.	12-25 fms.	261 fms. (av.)	A 23-20-8 fms.	-	F at 7 fms.
<i>Bulimina elongata</i> d'Orbigny	-	-	-	630-1425 fms.	-	-	VR <23 fms.	ndg.	-	-	-	R <28 fms.	-	-	-	VR >88 fms.	-	-	VR 35-40 fms.	12-30 fms.	-	-	-	-
<i>Bulimina pupoides</i> d'Orbigny	C <50 fms.	R, ndg.	-	0-1000 fms.	R, ndg.	R 40 fms.	F <23 fms.	787 fms. (av.)	-	-	-	-	-	-	-	VR >152 fms.	-	C 5-8 fms.	GD, ndg.	A <20 fms.	185 fms. (av.)	-	-	7 fms.
<i>Entosolenia laevigata</i> (Reuss)	C 40-50 fms.	-	-	2-3125 fms.	C, ndg.	F 260 fms.	R <23 fms.	ndg.	-	-	10-18 fms.	-	-	-	-	-	-	-	-	A 12-30 fms.	deeper water	-	-	-
<i>Bolivina variabilis</i> (Williamson)	-	R, ndg.	VR in brackish-waters	-	-	-	R <23 fms.	ndg.	-	613, >1000 fms. R 40-50 fms.	ndg.	C <28 fms.	-	-	-	-	-	5-85 fms.	GD, ndg.	C <60 fms.	R 11-20, 100, 750 fms.	-	-	-
<i>Virgulina schreibersiana</i> Czjzek	R <50 fms.	VR, ndg.	-	10-3000 fms.	GD, ndg.	R 940 fms.	-	834 fms. (av.)	-	-	-	VR 28 fms.	-	-	286 fms. (av.)	189 fms. (av.)	-	ndg.	35-40 fms.	12-25 fms.	-	150-1000 fms.	687 fms.	F 7-1020 fms.
<i>Valvulinaria araucana</i> (d'Orbigny)	-	-	-	shallow water	-	-	-	ndg.	377 fms. (av.)	-	-	-	-	-	-	-	-	ndg.	-	-	-	150-1000 fms.	-	-
<i>Cibicides refulgens</i> Montfort	-	R 30-40 fms.	-	45-2400 fms.	C >20 fms.	-	-	159 fms.	-	-	-	<28 fms.	-	-	244 fms. (av.)	C 175 fms.	-	R <85 fms.	GD, ndg.	<60 fms.	142 fms. (av.)	-	<100 fms.	R 50, 53 fms.

LEGEND

VR - VERY RARE.
R - RARE.
F - FREQUENT.
C - COMMON.
A - ABUNDANT.
VA - VERY ABUNDANT.

fms. - FATHOMS.
ndg. - NO DATA GIVEN
GD - GENERALLY DISTRIBUTED
av. - AVERAGE
* - SEE PAGE 193

infraneritic environment, with water depths from 120 to 600 ft. (20 - 100 fathoms). Using this terminology, it is here suggested that the basal Middle Headon beds in the east (Whitecliff Bay area) were deposited in an infraneritic environment, while those in the west (Colwell Bay and Headon Hill areas) were deposited in a near-shore, epineritic environment. The distribution of the environments during the deposition of the Headon beds are shown in Plate XIV.

In order to evaluate the evidence furnished by the foraminiferal fauna, ecological data (including bathymetric ranges) were collected for various species found in the British Oligocene material which also occur in the present-day seas. This data is given in Table 7. Species which are very rare in occurrence have been omitted. Average depths have been calculated in cases where it is possible to do so. In calculating these averages, occurrences below 1000 fathoms have been omitted, as most of the species found in the material studied are characteristic shallow-water forms and have been recorded in great abundance in depths less than 100 fathoms. The few anomalous occurrences from deep-waters may perhaps be due to these species having been washed from shallow waters. The only exception is Ammobaculites agglutinans (d'Orb.) which is more common in deeper-water.

Although a number of older references have been included in Table 7, most of them give only the minimum and maximum depths at which these species are found and are, therefore, of comparatively little help in estimating average depths. With regard to the ecological data given by Brady (1884), Glaessner (1948, p.184) states - "it should be remembered that they refer to a much wider concept of genera and species than that accepted in modern taxonomy." It must also be remembered that many of the older records of species may be based on misidentifications which cannot be checked, as the types are either lost or inaccessible.

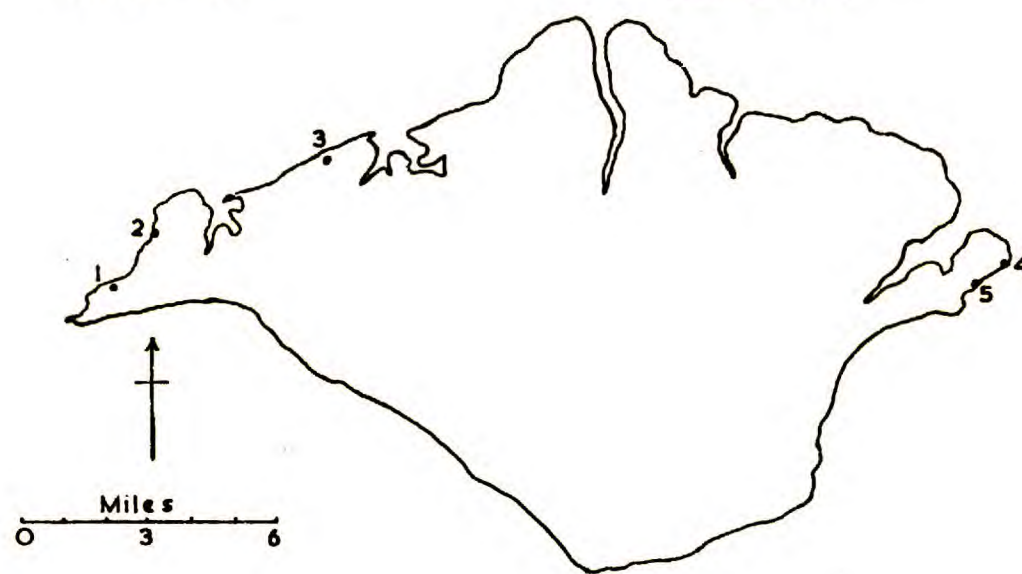
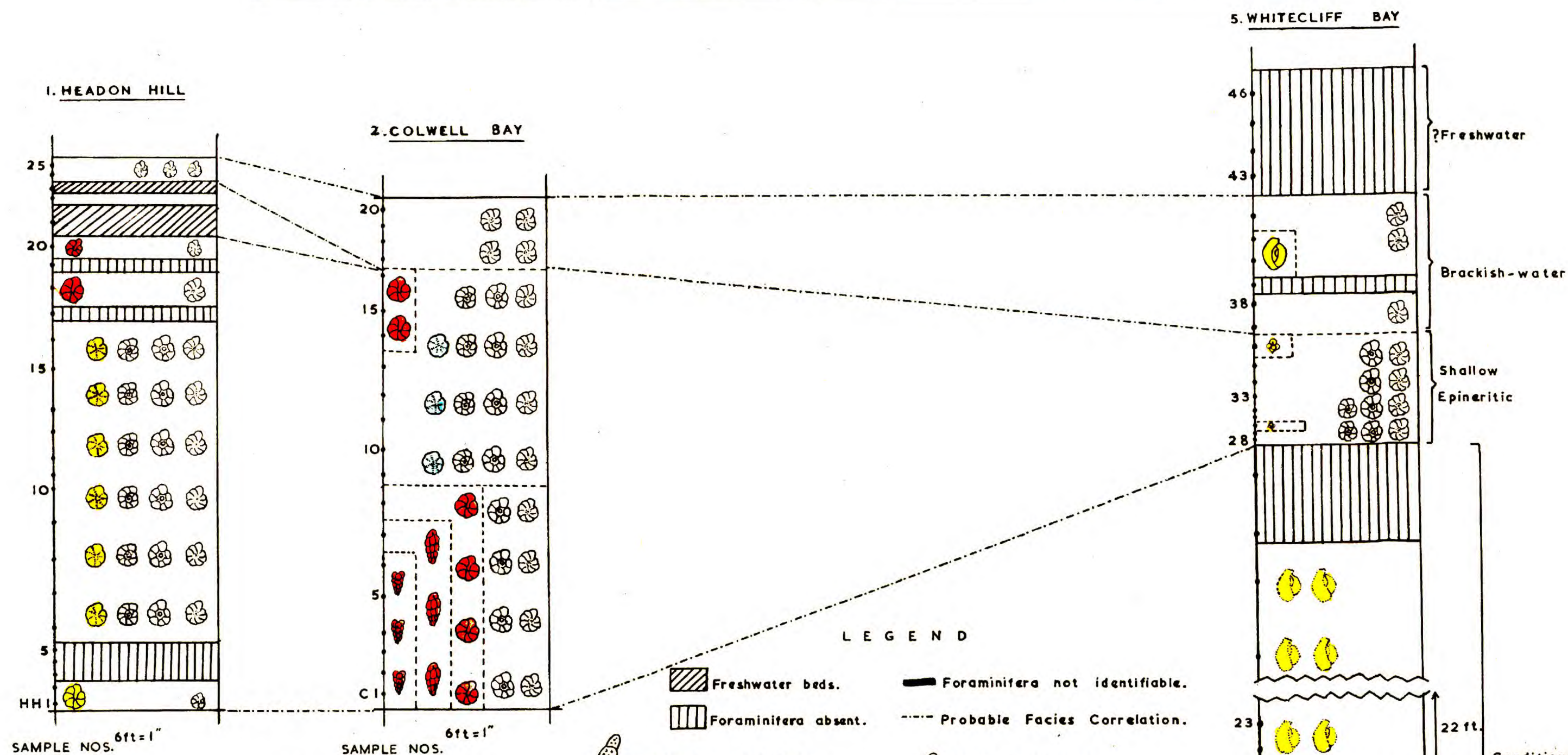
1) THE MIDDLE HEADON BEDS.

(a) Whitecliff Bay section..

The Brockenhurst and Roydon Zones :- The Brockenhurst beds, which form the base of the succession in the Whitecliff Bay section, contain the richest and most varied of the foraminiferal faunas to be found in the late Palaeogene sediments of the Isle of Wight. They can be subdivided, both lithologically and faunally, into two zones (Keeping and Tawney, 1881, p.109), a lower or Brockenhurst 'zone' s.s., and an upper or Roydon 'zone'. The former consists of some two feet of chocolate coloured clay dominated by Cibicides aknerianus, C.refulgens,

Globigerina sp., and Nonion umbilicatus ; the latter of some twelve feet of brown sandy clay containing abundant Pararotalia subinermis and Rotalia canui. The Roydon zone contains two bands in which members of the Miliolidae are concentrated (see samples W12 and W15), but with the exception of Quinqueloculina juleana and Triloculina trigonula, they are not individually abundant. The Polymorphinidae are fairly evenly distributed throughout both zones. Although this family is represented by numerous species, the number of individuals is in no case large. Other families represented are the Buliminidae, Rotaliidae, and the Anomalinidae, several members of which are restricted to the Brockenhurst and Roydon zones in the Whitecliff Bay section.

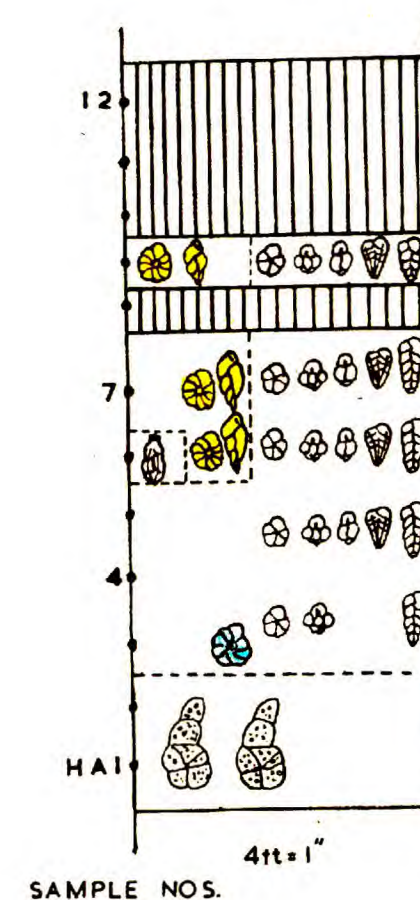
On the whole the Rotaliidae and the Anomalinidae are the dominant families represented in the Brockenhurst and Roydon zones. According to Norton (1930), these families do not seem to possess any definite ecological significance. Recent work has shown, however, that consideration of groups of family rank seldom permits the recognition of ecological controls. Since even members of the same genus are liable to show wide differences in degrees of tolerance to depth, temperature, salinity, etc., ecological deductions must be based on considerations of species and varieties if valid conclusions are to be reached.



Generalised Vertical Sections showing the Distribution
of Zonally Significant Foraminifera.

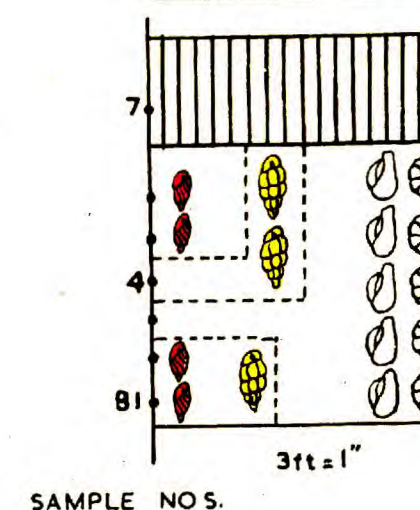
HAMSTEAD CORBULA BEDS

3. HAMSTEAD HILL



BEMBRIDGE OYSTER BEDS

4. BEMBRIDGE LEDGE



Although Cibicides refulgens and C.aknerianus are found in both the Brockenhurst and Roydon zones, they reach their maximum abundance in the former. Of the two, C.aknerianus is usually predominant, and near the top of the Brockenhurst zone (sample W10) constitutes some 60.0% of the assemblage. Neither of these species are found in the beds above the Roydon zone in the Whitecliff Bay section, and except for a few rare specimens of C.refulgens in the Headdon Hill samples (HH10 and HH13) are unrepresented in the other Middle Headdon sections examined.

Little is known concerning the bathymetric range of C.aknerianus, as the species does not occur in present-day seas. The Recent records by Brady (1884,p.663) have been discredited (vide etiam Thalmann, 1932). However, since the species occurs abundantly with C.refulgens, their bathymetric distribution must be similar. C.refulgens is a moderately shallow-water form, and occurs commonly round the margins of temperate seas below 20 fathoms. The shape and construction of the tests suggests that both these species lived on the surfaces of broad fronded seaweeds. Since luxuriant algal growth is usually found in the oxygenated waters of the brachyhaline zone (16.5 - 30 ‰ salinity, vide Hiltermann, 1949), the occurrence of these two species would indicate deposition in waters of almost normal salinity and oxygen content. This is in accordance

with the views of Lowman (1949) who states that Cibicides is the most abundant genus in the mid-neritic zone.

Further ecological information is furnished by the distribution of Globigerina sp. The percentage of this species is at a maximum of 27.1% at the base of the Brockenhurst zone, and disappears just above the base of the Roydon zone. It is not represented in the higher beds of the Whitecliff Bay section, and neither does it appear in the Middle Headon beds of Colwell Bay and Headon Hill. Globigerina is a pelagic form and its normal habitat is the surface waters of the open sea. It is not normally found in shallow turbid coastal or estuarine waters in the temperate zones, but is liable to be swept into them from the oceans by the action of tides and currents. The occurrence of significant percentages of Globigerina in a deposit, therefore, is not necessarily an indication of accumulation at great depth but rather an indication that the area of deposition was in unrestricted communication with the open sea. The occurrence of Globigerina in the Brockenhurst and Roydon zones and its absence from the 'Barren' sands and 'Venus' beds is thus an indication that the area of deposition was becoming progressively cut off from direct communication with the open sea with passage of time; and almost certainly indicates that the Whitecliff Bay area was progressively silting up. The absence of

Globigerina from the other Middle Headon areas similarly indicates that the deeper-water conditions apparent during the deposition of the Brockenhurst and Roydon zones at no time existed in these areas, and supports the hypothesis that the marine Middle Headon transgression came from the east via Whitecliff Bay.

Another ecologically significant species found in the Brockenhurst and Roydon zones is Nonion umbilicatus. This is typically a deeper, cool-water form, and is not normally found in shallow coastal sediments. It occurs abundantly at depths over 50 fathoms, and according to Brady (1884) is found in much deeper water than its ally N.depressulus. The abundance of N.umbilicatus in the basal samples of the Brockenhurst and Roydon zones supports the assumption that these beds were laid down in deeper and more saline waters than the succeeding beds.

As has been mentioned previously, the Polymorphinidae are well represented in the Brockenhurst and Roydon zones. Although this family has a wide bathymetric distribution in present-day seas, it is most abundantly represented in both number of species and individuals in the deeper neritic waters. It is not commonly represented in very shallow waters of low salinity and does not appear to tolerate waters of abnormally low oxygen content. The two best known Recent forms that occur in the Isle of Wight material -

Globulina gibba and G. inaequalis - are both typically marine species, and occur most abundantly in the deeper waters of the neritic zone. Members of this family are not found in the Middle and Upper parts of the 'Venus' beds, indicating that conditions at the time of the deposition of the latter had become unsuitable for their survival. It seems likely that the factors governing their disappearance were the changes in depth and possibly salinity during the silting up of the Middle Heaton sea.

Examination of the distribution of Cibicides refulgens, C. aknerianus, Globigerina sp., and Nonion umbilicatus in the Whitecliff Bay section (see Table I) indicates that these forms are the most abundant in the clays of the Brockenhurst zone, and that these beds were laid down in slightly deeper, cooler waters than the sandy clays of the succeeding Roydon zone.

Ecological conditions during the deposition of the Roydon zone appear to have been slightly different to those pertaining during the accumulation of the underlying clays. Although the differences between the Roydon and Brockenhurst faunas are to some extent due to a slight shallowing in the depth of the sea (as indicated by the decrease in abundance of Nonion umbilicatus, Globigerina sp., and Cibicides spp.) It seems unlikely that this would account for the sudden appearance in abundance of Rotalia canui and Pararotalia

subinermis. Some additional factor is probably involved, and in view of the close correspondence between the faunal and lithological changes, it is suggested that the factor in question is the nature of the substratum supporting the assemblage.

Nothing is known concerning the distribution of Rotalia canui and Pararotalia subinermis, since neither species has survived to Recent times. However, these species show certain resemblance to several groups of late Tertiary and Recent species, the ecological significance of which is known. The similarities in test construction and constitution (spinosity, thickness of walls, heaviness of ornamentation, etc.) suggests that they probably thrived under similar conditions. Perhaps the commonest of the Recent allied species is 'Rotalia' calcar d'Orbigny. An examination of the literature suggests that this species is confined to warm tropical marine waters and thrives best on coarser sediments in well oxygenated lime-rich environments. According to Brady (1884, p.709) it is commonly found in shallow water coral sands in the East and West Indies, and he also records it from the Mediterranean and Red seas, off Mauritius, Ceylon, and the Cape of Good Hope. It has also been recorded by Norton (1930, p.352) from Murray Island, Australia; he states that the species seems to have definite ecological relations, and is practically

confined to shallow warm waters.

These inferences are also supported by recent work on the distribution of Pararotalia serrata (ten Dam and Reinhold) in the Pliocene Coralline Crag of East Anglia, (D.J.Carter, personal communication). The distribution of this form (which is closely related to P. subinermis) has been found to be governed in part by the lithology of the enclosing sediments, and it appears that this species only becomes abundant where a shallow-water current-swept sandbank facies is developed.

If the parallel that has been drawn between Rotalia canui and Pararotalia subinermis on the one hand, and the Recent and Pliocene species on the other is valid, then it is probable that the sudden appearance of the two former species may well be correlated with the change in conditions which initiated the deposition of the coarser sediments of the Roydon zone.

An interesting feature of the Roydon zone is the appearance within it of members of the Miliolidae. These become particularly concentrated at the level of samples W12 and W15 and constitute 31.4% and 14.2% respectively of the contained assemblage. In these two samples, the family is represented by 9 species. The dominant form in sample W12 is Quinqueloculina juleana which accounts for 26.9% of the total foraminiferal assemblage.

Triloculina trigonula is the next abundant species and constitutes 3.6% and 3.3% of the contained assemblages in samples W12 and W15 respectively.

The ecological conditions that governed the distribution of the individual species of the Miliolidae represented in the Miliolid bands are not certainly known. The dominant species represented - Q. Juleana - has not been reported from recent seas. The most detailed and comprehensive ecological data concerns the distribution of Q. seminulum. According to Said (1951, pp.82 and 85), who worked on the foraminifera of Narragansett Bay, on the coast of Rhode Island, the distribution of this species is dominantly controlled by salinity. He found it to be characteristic of a zone of intermediate salinity representing the transition between Hiltermann'sⁿ pliohaline and brachyhaline zones (9 - 16‰ and 16.5^{-30 ‰}‰ salinity respectively - vide Hiltermann, 1949, pp.4-8). This distribution coincides with that in Jade Bay, N.W. Germany, described by Bartenstein (1938, p.399, table Ib). It must be remembered, however, that although Q. seminulum is the most abundant in the zone of intermediate salinity, it is by no means restricted to it. In North America and Europe, the species is widely distributed in the shallow temperate coastal waters of normal salinity.

Other Recent Miliolidae which are found in the

Roydon miliolid bands are Miliolinella Oblonga, Triloculina trigonula and Quinqueloculina bicarinata. Of the three, M.oblonga and T.trigonula are perhaps the most widely distributed species. Although M.oblonga has a wide bathymetric range, the majority of records are from depths of less than 50 fathoms. It has also been reported from very shallow waters of subnormal salinity (Brady, 1870). Natland (1933) records T.trigonula at depths ranging from 20.3 to 150 fathoms. No detailed ecological data is available for Q.bicarinata, but records of occurrences suggest that it is typically a shallow-neritic species.

A survey of the rather limited information concerning the distribution of these species would seem to indicate that the sediments comprising the miliolid bands were laid down in an inner-neritic environment, possibly at depths of less than 50 fathoms. This is in accordance with the information concerning the distribution of the Miliolidae as a whole given by Norton (1930, p.339), who states that "the most favourable habitat for members of the Miliolidae is in warm, shallow water and tropical and warm temperate seas in depths down to perhaps 50-60 fathoms, where the temperature ranges between 20° and 26°C."

Although the appearance of miliolids in the Roydon zone as a whole may have been dependent on the slight shallowing of the sea (indicated by the distribution of

Cibicides spp., Globigerina sp., and Nonion umbilicatus in that zone), it seems unlikely that it could account for the fairly high percentage of miliolids in samples W12 and W15. It seems more likely that this high percentage should be ascribed to some sudden ecological change during the deposition of the Roydon zone. A local current change which resulted in the reduction of the salinity of the water may have been responsible for the increase in abundance of the Miliolidae, but it is probable that some other ecological factor hitherto not considered was involved.

Although the Miliolidae are the most abundant foraminifera in shallow water in coral reef regions, they tend to be somewhat locally distributed within these areas. Cushman and Valentine (1930, p.5) note that ~~in~~ ^{of the bay} ~~Bay~~ the miliolids are plentiful on the one side, but are nearly absent on the other. The findings of Dawson (1870) in the Gulf of St. Lawrence are interesting in this respect, for he states that the Miliolidae, although abundant in the shallow partially land-locked sheltered Gaspe Bay, are characteristically and almost entirely absent from the current swept area outside the bay. In the light of Dawson's remarks on the effect of currents it is possible that the distribution of the miliolids in the miliolid bands may have been governed by a momentary moderation of current action in the area.

It has been suggested (van Voorthuysen, 1949,p.67, re Q.seminulum) that the abundance of certain miliolids may be largely controlled or affected by food supply. Unfortunately, variations in food supply, except in so far as they are related to changes in lithology and organic content of the substratum, cannot be determined by study of the enclosing sediments; verification of this hypothesis will therefore have to wait detailed studies on the distribution of living specimens.

With regard to the composition of the assemblage from samples W12 and W15, it is interesting to note that an increase in the abundance of miliolids is accompanied by a marked reduction in the percentage of Cibicides aknerianus. It is therefore probable that the ecological factor which favoured the abundant development of the miliolids was precisely the one which inhibited the development of C.aknerianus. Although the ecological factor involved could be a sudden decrease in the depth of water during the accumulation of the enclosing sediments there are many other alternatives. Carter (1953), who found a similar relationship between the distribution of Q.seminulum and Cibicides spp., in samples from the Holocene Estuarine clays of Northern Ireland, suggests that the controlling factor may be variations in the abundance of algal growth.

Although the evidence furnished by the foraminifera indicates that the Roydon zone was laid down in somewhat shallower water than the underlying Brockenhurst zone, the evidently richer and more varied fauna of these two zones (in contrast to the assemblages of the west coast sections) indicates a comparatively deeper-water, infraneritic to epineritic environment for their deposition. An analogy may be drawn from the Gulf Coast region, where Lowman (1949, p.1956) distinguished several facies-zones, based on the abundance of certain foraminifera. The inner neritic zone or near-shore area is characterised by the abundance of Rotalia, Elphidium, and various members of Miliolidae, whereas the mid-neritic zone is characterised by the abundance of genera and species of Rotaliidae, especially Cibicides.

In view of the absence of inland exposures of the Brockenhurst beds in the Isle of Wight, it is not possible to know the exact lateral limit of its infraneritic / deep epineritic depositional environment.

The 'Barren' sands :- Soon after the deposition of the Brockenhurst beds, the sea gradually began to retreat eastwards and partial silting up of the area took place. As a result of these changes in physical conditions, beds which succeed the Brockenhurst beds (in the eastern area) consist entirely of coarse-grained greyish-green sands (76 ft) with occasional bands of ironstone nodules. They are

unfossiliferous, except for some obscure casts of miliolids (probably Q.seminulum) and casts and corroded fragments of marine molluscs.

The miliolid casts are made up of minute spherules of black iron pyrites. Myers (1942, p.34) states, concerning the black pyrites of iron (found in foraminiferal tests in certain regions off Plymouth, England)- "It is presumed that this mineral is produced in subsurface sediments when anaerobic bacteria utilize sulphates as a source of oxygen and release hydrogen sulphide which in turn produces the pyrites from soluble iron salts. The occurrence of the pyritized tests may be related to the bacterial decomposition of the protoplasm of the foraminifera that had died as a result of being buried during periods of turbulence or when the bottom was disturbed by strong currents." It is possible that the pyritized miliolid casts in the 'Barren' sands were also produced under the same conditions as those outlined by Myers.

It is interesting to note that in the 'Barren' sands and in the Roydon zone (sample W13), miliolids are the only fossils that are found in the form of casts in pyrite. If Myers' surmise concerning the method of formation of pyrite casts is correct, this would suggest that the Miliolidae are particularly liable to be buried during the periods of turbulence or current action, possibly through inability of the protoplasm to disengage itself from enclosing sediments.

The absence of foraminiferal remains other than miliolid casts in the 'Barren' sands should not be construed as an indication that the environment during the deposition of these beds was inimicable to foraminiferal life. It is more probable that the absence of organic remains is secondary and is due to the lithology and structural attitude of the sediments. The 'Barren' beds consist entirely of coarse-grained sands and consequently offer no hindrance to the passage of percolating water. They occur in a succession consisting largely of clays and sandy clays, and the whole succession in Whitecliff Bay has been sharply folded, so that it dips at an angle of 75° . Any waters percolating downwards would have been canalised through the sandy beds leading to the decalcification of the contained fossils.

In the absence of foraminiferal remains other than the miliolid casts, it is impossible to deduce the ecological conditions during the deposition of the 'Barren' sands. In view of the decalcification subsequent to deposition, too much emphasis must not be placed on the occurrence of the miliolid casts. The heavy fractions of some samples from the Roydon zone usually contain similar miliolid casts, and if these beds ^{had} suffered complete decalcification the remaining organic content would closely resemble that of the 'Barren' sands. Similarly the scarcity or absence of foraminiferal remains at the top of the Brockenhurst zone (sample W11)

and the middle part of the Roydon zone (W13, W14) does not indicate that environmental conditions during the deposition of these layers was inimical to foraminiferal life. The frequent occurrence in these samples of dehydrated selenite crystals points to subsequent destruction of the calcareous contents by acidified waters.

The 'Venus' beds :- The 'Venus' beds in the Whitecliff Bay section are divisible into three lithologically distinct portions. At the base is a 4ft. bed of stiff blue clay containing abundant molluscan remains. This is overlain by 20ft. of bluish-green sandy clay containing Cordiopsis incrassata. The topmost bed consists of sandy loam (12ft.), devoid of organic remains except for a few indistinct molluscan casts. As in the Brockenhurst and Roydon zones, the contained foraminiferal faunas appear to be largely controlled by the lithology of the enclosing sediments, so that the boundaries between the faunal zones coincide with those between the three lithological subdivisions.

The stiff blue clay at the base of the 'Venus' beds marks the disappearance of the characteristic deeper-water marine species found in the lower beds, the first appearance in the succession of Rotalia viennensis, and the first appearance in marked abundance of Rotalia sp. aff. papillosa and Nonion depressulus. An interesting feature of this clay bed is the appearance within it of two bands containing

concentrations of foraminiferal species (Q.seminulum and Buliminella carteri respectively) not found in abundance elsewhere.

Of the above species, N.depressulus is the most widely distributed in recent seas. From the Table 7, it will be seen that this species is usually frequent at depths of less than 150 fathoms. Brady (1884) states that it is most abundant at depths less than 50 fathoms. This, in fact, is true of most of the records of the species from around the British Isles. N.depressulus is also remarkable in that it exhibits a very high degree of tolerance to waters of low salinity (Brady, 1865, 1870, 1884, 1887; Hada, 1936). N.depressulus associated with Elphidium excavatum (Terquem) (= Polystomella striatopunctata auctorum) has actually been reported from grassy fresh water pools receiving land drainage (Brady, 1870, p.278). This euryhaline species is also a very important constituent of assemblages living in waters of extremely low oxygen content, and is common in the Holocene stagnant-water clays of the Netherlands (van Voorthuysen, 1951, Diagrams nos.1 & 2). In stagnant waters of very low salinity, however, it is usually accompanied by Trochammina and Haplo-phragmoides, which are not represented in the Isle of Wight assemblages.

Little is known concerning the ecology of Rotalia sp. aff. papillosa and Rotalia viennensis which do not occur in

the present-day seas. Hantken (1867) records R.viennensis from Oligocene brackish-water deposits of Hungary. Since this record is without any figure or description, the identification must be taken as doubtful. From the type locality in the Vienna Basin, the species is frequent in the Sarmatian (Upper Miocene) sediments. Marks (1951, p.33) states - "The Tortonian passes upwards into the Sarmatian sediments of shallow to brackish water facies, containing Cerithiae, Tapes, etc. The almost exclusive occurrence of various species of Elphidium and Rotalia clearly indicates a shallow water depositional environment."

The disappearance or marked decrease in abundance of many forms in the lower 'Venus' bed clays appears to indicate that conditions during deposition had become less favourable to the development of a rich and varied foraminiferal fauna. Such conditions are usually to be found in epineritic, very shallow pliohaline coastal waters, where the decrease in salinity due to dilution of the sea water by land drainage is becoming appreciable. Assemblages subsisting under these conditions typically contain small numbers of species represented by large numbers of individuals, and are usually dominated by Nonion, and Rotalia.

A notable feature of the 'Venus' bed clay is the occurrence within it of a band containing a very high percentage of Buliminella carteri (83.0%). Unfortunately

this species is not represented in recent seas, and no information is available concerning the factors controlling its distribution. Although the genus is typically a shallow-water form, its species inhabit too wide a range of environments to allow accurate deductions based solely on the genus to be made. However, it is interesting to note that the conditions which favoured the increase in abundance of B.carteri caused a marked reduction in the abundance of N.depressulus and Rotalia viennensis. It is therefore possible that a localised increase in depth (or more probably salinity) may be responsible. In view of the recurrence of a very similar assemblage at one level in the more brackish-water overlying sandy clays it seems more likely that some factor other than salinity or depth is responsible.

In sample W32 from the top of the clay, the percentage of N.depressulus decreases very markedly concurrently with the sudden appearance of Quinqueloculina seminulum and Q.impressa var. cognata. In this sample N.depressulus constitutes over 50% of the assemblage. The conditions which govern the distribution of Q.seminulum have already been discussed (see p.183). The misconception that Q.seminulum is a species which thrives in waters of very low salt content appears to rest on a misidentification in "The Ostracoda and Foraminifera of Tidal Rivers", Pt.11.

(Brady, 1870). In this publication certain thin-shelled forms approaching Miliolinella subrotunda (Montagu) in appearance, found in association with Miliammina fusca (Brady), a typical brackish-water form, were erroneously included in Q.seminulum s.s. If the remarks concerning these forms are eliminated, Brady's statement (op.cit. p.285) on the distribution of Q.seminulum becomes "Typically shallow marine" and thus more closely in accordance with present-day information. It has already been pointed out, however, that another factor independent of salinity may be involved, and in view of a recurrence of a very similar assemblage in more brackish-water higher beds this seems to be a more likely explanation.

The bluish-green sandy clays with Cordiopsis incrassata contain a very restricted fauna, and a study of the foraminiferal assemblages reveals a sudden progressive reduction in the salinity of the water during the deposition of the upper beds. Other faunal changes occurring at the boundary between the underlying clays and the sandy clays may be correlated with a sudden decrease in salinity and/or oxygen content of the water or with the change in lithology.

The assemblages in the sandy clays are dominated by the two species - Rotalia viennensis and Nonion depressulus. In the lower parts of the section the former is the most abundant, but it disappears about 4 ft. above the base. In

the upper part of the section N.depressulus is the dominant form and at some levels (see W.37, W.38, and W42) the assemblages become monospecific. This would seem to indicate that not only was the water becoming more brackish with the passage of time but it was also tending to become stagnant. Such conditions are commonly found in shallow turbid estuarine areas where abundant plant remains and organic refuse tend to reduce the oxygen content of the water. In coastal brackish-water lagoons characterised by sluggish or non-existent water circulation, and water of very low oxygen content, Nonion / Trochammina / Haplophragmoides assemblages would be produced.

The progressive decrease in salinity during the deposition of the upper sandy clay 'Venus' beds (as indicated by the increase in percentage of Nonion depressulus) is in accordance with the views of Stamp (1950, p.292) that the initial marine invasion during the Oligocene in English and French regions was followed by a considerable period during which brackish-water and eventually freshwater conditions prevailed.

A significant feature of the sandy clays is the occurrence in them of assemblages rich in Buliminella carteri and Quinqueloculina seminulum. The former was found in the mid-portion of the sandy clay succession, and the latter near its top. These assemblages are closely similar to those found in the underlying blue clays, and it is

noteworthy that the assemblages occupy a similar spatial position relative to the base of the individual bed in which they occur. The conditions which gave rise to them probably tended to recur in the same order in each lithological phase, and are therefore to some extent oscillatory. The green sandy loams overlying the sandy clays appear to be totally devoid of foraminiferal remains. The heavy fraction of W43 was found to contain pyrite, but this was not in the form of foraminiferal casts. The occurrence in these beds of fragmentary corroded mulluscan remains and obscure molluscan casts indicate that organic remains were present in the beds at the time of deposition and have subsequently been removed by percolating water. If however, the trend away from marine conditions during the deposition of the underlying beds was continued, the sandy loams would probably have been laid down in almost fresh water. In such an environment foraminifera are usually not found, and therefore it is possible that these deposits did not originally contain them.

(b) Colwell Bay and Headon Hill sections :- The foraminiferal faunas of the Middle Headon beds of the Colwell Bay and Headon Hill sections, though limited in the number of species, consist of abundant specimens of Nonion depressulus, Rotalia viennensis, Rotalia sp.aff. papillosa, and

Elphidium minutum. The first two species together usually constitute over 60% of the total assemblage in different samples. Valvulineria araucana is virtually restricted to the Colwell Bay and Headon Hill sections, where it attains abundance in a few basal samples. Other species are too rare to be of any significance. Valvulineria araucana is reported from 150 - 1000 fathoms (Natland, 1930). According to Brady (1884), however, it is a shallow water species. Excepting two samples (C3 and HH2), the percentage of this species does not exceed that of N.depressulus or R.viennensis. It is therefore probable that V.araucana occupied the same ecological niche as that occupied by N.depressulus and R.viennensis.

As in the Whitecliff Bay section, the percentage of N.depressulus increases markedly in the upper samples, both in the Colwell Bay and Headon Hill sections (samples C17 - C20 and HH24, HH25 respectively). In the Colwell Bay samples, it is over 96% and at Headon Hill, over 86.7%. Further, the same samples contain abundant specimens of the gastropod Theodoxus concavus, which lives in brackish and fresh waters (Davies, 1935, p.228; Wood, 1947, p.283).

The foraminiferal (as well as mulluscan) evidence, therefore, suggests that the Middle Headon beds in the Western areas (Colwell Bay and Headon Hill) were initially

deposited under shallow marine conditions at depths less than 50 fathoms. During the deposition of the upper part of the Middle Headdon beds, however, the rapidly shallowing sea gave place to lagoonal or brackish-water conditions, as shown by the abundance of brackish-water fossils.

The Middle Headdon beds pass imperceptibly into the overlying freshwater Upper Headdon beds, indicating the gradual retreat of the sea and the establishment of freshwater conditions. The Osborne beds and the Bembridge Limestone also belong to the freshwater phase and are complementary to the marine phase of the Middle Headdon beds.

2) THE BEMBRIDGE OYSTER BEDS.

The Bembridge oyster beds were deposited during the second marine cycle, under the same environmental conditions that prevailed during the deposition of the Middle Headdon beds in the western area, i.e. a near-shore, epineritic environment. This marine transgression, however, was of shorter duration than the previous one, and continental conditions were soon re-established. The foraminiferal fauna is similar to that of the Middle Headdon beds of Headdon Hill and Colwell Bay sections. Some species which are rare in the Middle Headdon beds, however, become abundant here. These are Miliolinella oblonga, Buliminella elegantissima and B. striato-punctata. N. depressulus is again the

dominant species, and occurs in most of the samples in super-abundance. M.oblonga, though having a wide bathymetric range, is very common in shallow waters with depths less than 50 fathoms. Natland (1933) recorded both M.oblonga and B.elegantissima in abundance from zone II, with a depth range from 2 to 20 fathoms, which is virtually the range of the epineritic environment, as suggested by Scott (1940). Most of the other records of B.elegantissima from around the British Isles, off the coast of Belgium, and the eastern coasts of North and South America are from depths less than 50 fathoms. According to Hada (1936), the species can also live in brackish-waters.

The continental Bembridge beds comprise a great thickness of clays and grey-blue marls, the Bembridge marls. Within this phase may also be included the lower, middle and upper Estuarine and Freshwater Hamstead beds, which are merely a continuation of the Bembridge marls and differ from them mainly in lithology - sandy beds and shales replacing the marls and clays.

3) THE HAMSTEAD CORBULA BEDS.

The uppermost 20 feet or so of the Hamstead series - the Hamstead Corbula beds - represent the third and the last important marine phase of late Palaeogene sedimentation.

Of the Recent species found in the Hamstead Corbula beds, the dominant forms are Ammobaculites agglutinans, Miliolinella oblonga, Nonion depressulus, Nonionella auricula, Buliminella elegantissima, Bulimina pupoides, Bolivina variabilis and Virgulina schreibersiana.

A. agglutinans is rather abundant in the two basal samples (63.6% and 84.1%). Though the species has a wide bathymetric range, the deeper-water records are more numerous than those from shallow waters. Around the British Isles, however, the species occurs in shallow waters, at depths less than 50 fathoms (Brady, 1887). According to Heron-Allen and Earland (1910, p.422), it cannot be described as a common British species. Hada (1936) records the species in great abundance from brackish-water lakes in Japan, with salinity ranging from 12.0 to 33.5‰. Lowman (1949, p.1953) states "The foraminiferal genus Ammobaculites is the dominant genus in what may be classed as weakly brackish environments in the range from 100 to 5000 parts per million chloride". It seems highly unlikely that the basal Hamstead Corbula beds were deposited in very deep waters, as the associated faunule contains no other deeper-water species. The possibility of a brackish-water environment, however, cannot be ruled out completely. The state of preservation of this species indicates a shallow-water depositional environment. The shells are very fragile, and out of over 600 specimens

that were found, only 3 have the uniserial portion intact. Heron-Allen and Earland (op.cit., p.424) state concerning Ammobaculites (Haplophragmium) agglutinans - "The shell is constructed with a peculiarly perishable cement which conduces to its disintegration under the action of waves upon the shore and the process of drying and floating". Since the specimens of this species occur in a very fragmentary state, it appears probable that the basal Hamstead Corbula beds were deposited in very shallow marine waters, where, due to the action of waves, the fragile shells were partially disintegrated. The exact or even an approximate estimate of the depth is of little importance, because the species inhabits a wide range of ecological conditions.

The Buliminidae are abundantly represented in these beds, both by the number of species and the number of individuals. According to Norton (1930, p.348) the members of the family "are not restricted as regards conditions of depth and temperature". However, two species seem to be of ecological value. These are Buliminella elegantissima and Bolivina variabilis. The former species, as already remarked, occurs abundantly at depths less than 50 fathoms, the optimum range being 2.3 - 20.8 fathoms. B.variabilis is typically developed and abundant around the British Isles (the types were from off the south coast of England). Except for deeper-water records by Cushman (1942) from the Pacific 'Albatross' collection at depths ranging from 613 to 1135

fathoms, all the other records are from depths less than 85 fathoms. Off the Belgian coast, the species occurs commonly at depths less than 28 fathoms (Cushman, 1949). B.elongata and Virgulina schreibersiana, though somewhat abundant in some samples, have bathymetric ranges too wide to be of any ecological value.

In the upper samples, Nonionella auricula occurs commonly. Though there are few records of the species, it appears to be restricted to, and abundant in, shallow waters. Heron-Allen and Earland (1930) record the species from off Plymouth, England, at a depth of 30 fathoms. Cushman (1949) records it from several stations in the Atlantic Ocean, off the New England coast, at depths ranging from 6 - 13 fathoms.

Thus the foraminiferal evidence suggests a relatively shallow marine environment (with depths less than 50 fathoms) for the deposition of the Hamstead Corbula beds.

In the preceding pages, an attempt has been made to select foraminiferal assemblages which yield information as to the nature of the environments prevailing during the deposition of the various marine or brackish-water beds of the late Palaeogene sediments. The ecological value of the foraminifera and the biotopes in which they occurredⁿ, are directly interpreted by analogy with Recent species and modern environments.

IX. (A) SPECIES COMMON AND PECULIAR TO THE
MARINE BEDS OF THE LATE PALAEOGENE
SEDIMENTS.

- I. Out of a total of 62 species and varieties found in the marine beds of the late Palaeogene sediments, there are :-
 - 6 species common to the three marine beds, (namely the Middle Headon, Bembridge Oyster and Hamstead Corbula beds.
 - 7 species common to the Middle Headon and Bembridge Oyster beds.
 - 13 species common to the Middle Headon and Hamstead Corbula beds.
 - 6 species common to the Bembridge Oyster and Hamstead Corbula beds.
- II. Out of 47 species and varieties found in the 3 sections of the Middle Headon beds, there are :-
 - 2 species peculiar to the Headon Hill section
 - 2 species peculiar to the Colwell Bay section
 - 27 species peculiar to the Whitecliff Bay section.
- III. Out of 10 species and varieties found in the Bembridge Oyster beds :-
 - 3 species are peculiar to these beds.
- IV. Out of 24 species and varieties found in the Hamstead Corbula beds :-
 - 11 species are peculiar to these beds.

(B) STRATIGRAPHICAL RANGES OF SPECIES.

Since the marine Oligocene beds of the Isle of Wight are not very productive in foraminifera, the total number of species found in these beds is very small compared with the number in contemporaneous horizons in the European Tertiaries. For this reason, the number of species common to the Oligocene of the Isle of Wight and equivalent horizons in European localities is also very small.

Exact correlation on the basis of common species is therefore difficult and it is essential to apply the criterion of the known stratigraphic ranges of species. Only the first appearance of a species, coupled with its known ranges throughout limited stratigraphical thicknesses can be used effectively in any inter-regional correlations.

A statistical analysis of the various species found in the Oligocene beds of the Isle of Wight based on the above principles, reveals certain interesting features which are listed below. The localities and exact horizons from which the various species have been recorded in Europe have already been given in the systematic study (see VI).

I. Foraminiferal Fauna of the Middle Headon beds - 47.

species and varieties.

- (a) 4 species and varieties are new (and therefore of little value at the moment for correlation purposes).

- (b) 17 species and varieties have a wide geological range - either Eocene to Miocene or Eocene to Recent. Lagena sulcata is known to range from Cretaceous to Recent.
- (c) 1 species, Quinqueloculina bicarinata, has so far been recorded only from the Pliocene and Recent of Italy.
- (d) 9 species are known to appear first in the Oligocene and to range upwards to Miocene or Recent. These are Clavulina angularis, Nonion depressulus, Elphidium minutum, Rotalia viennensis, Valvulineria araucana, Bolivina variabilis, B. fastigia, Bitubulogenerina reticulata and Quinqueloculina juleana.
- (e) 3 species are found in the Oligocene of Germany and France, namely Bulimina coprolithoides, Quinqueloculina impressa var. cognata, and Rotalia canui. Except for one record of Bulimina coprolithoides from the Eocene beds of Italy, it is a characteristic Oligocene form.
- (f) 5 species occur in the Eocene of the Paris Basin, namely Quinqueloculina simplex, Q. pertusa, Globulina ampulla, Buliminella striato-punctata, and Valvulineria subconica.
- (g) The ranges of the rest of the species and varieties are doubtful.

II. Foraminiferal fauna of the Bembridge Oyster beds -
10 species.

- (a) 2 species are new.
- (b) Bulimina pupoides, Buliminella elegantissima and Miliolinella oblonga range from Eocene to Recent.
- (c) Nonion depressulus ranges from Oligocene to Recent.
- (d) Bulimina coprolithoides occurs in the Oligocene strata of Germany and France.
- (e) Buliminella striato-punctata occurs in the Eocene beds of France.
- (f) The rest of the species are too obscure for definite identifications.

III. Foraminiferal fauna of the Hamstead Corbula beds -
24 species and varieties.

- (a) 2 new species.
- (b) 8 species range from Eocene to Recent.
- (c) 1 species, Nonionella auricula, has so far been recorded only from recent seas.
- (d) 8 species have been recorded from characteristic Oligocene deposits in Germany, France and other countries, and range upwards to Miocene or Recent.
- (e) 3 species are characteristic Oligocene forms -
Angulogerina tenuistriata, Bolivina beyrichi var bituminosa, and Bulimina coprolithoides.

(f) Only one species - Quinqueloculina simplex - ranges up from the Eocene.

(g) The identification of the other species is provisional.

The fauna is very similar to the one described by Paalzow (1924), from the Middle Oligocene, Cerithien sands of Offenbach, Germany, and 7 species are common to both.

3 species are identical with those described by Spandel (1909), from the Rupelton beds of the Mainz Basin, Germany.

3 species are identical with those described by Reuss (1870) from the Middle Oligocene, Septarienthon of Pietzpuhl, Germany.

2 species are identical with those described by Cushman (1923) from the Oligocene (Stampien) of the Paris Basin, France.

X

CONCLUSIONS.

The statistical analyses given in the previous section show that although 10.6% of the total foraminiferal species in the Middle Headon beds are characteristic Eocene forms, 27.6% of the species are known to appear first in the Oligocene horizons; 6.3% of these are restricted to the Oligocene. The long-ranging species constitute 38.2% of the total species. As little reliance for correlation purposes could be placed on these long ranging species greater reliance should be placed on the younger forms ranging from Oligocene to Recent.

Although the fauna is to some extent of a transitional nature, it has in its elements a fairly large percentage of younger forms which have not been recorded from beds older than the Oligocene. The assembled data clearly indicates that the age of the Middle Headon beds must be younger than Bartonian. As will be shown later, the Hamstead Corbula beds are of Middle Oligocene age. On this basis, the Headon and Bembridge series should be assigned to the Lower Oligocene.

The foraminiferal fauna of the Bembridge Oyster beds is comparatively poor in number of species and is hardly reliable for purposes of exact correlation. Only one characteristic Eocene species, Buliminella striato-punctata was found in these beds. Nonion depressul^s~~um~~ is known to range from Oligocene to Recent. Bulimina coprolithoides is

known from characteristic Oligocene beds. Except for the new and doubtful species, the remainder are all long-ranging species. Here again, caution must be applied in using these species for stratigraphical correlation.

The Hamstead Corbula beds contain a foraminiferal fauna distinctly higher in the stratigraphical sequence than those mentioned previously. Except for a solitary species - Quinqueloculina simplex - which ranges up from the Eocene, 45.8% of the species have definitely been recorded from Oligocene and succeeding horizons. Of these, 12.5% are known from the Oligocene beds of Germany, France and other countries in Europe. The fauna shows very close affinities with that described from the Middle Oligocene of Pietzpuhl and Mainz Basin in Germany.

Sandberger (1862), on the evidence of the mollusca from the Hamstead Corbula beds, regarded them to be exact equivalents of the Middle Oligocene beds exposed at Jeurres, Weinheim and Bergh. von Koenen (1867a, p.507; 1867b, p.31) correlated these beds (along with the Bembridge series) with the Middle Oligocene beds of Hermsdorf, Sölingen, Cassel, Bünde and other localities in Germany.

The foraminifera also, so far as they are capable of comparison with other Oligocene horizons indicate that the Hamstead Corbula beds are of Middle Oligocene age. As remarked earlier, there is limited foraminiferal evidence

to suggest that the Middle Headon beds and the Bembridge series should be retained in the Lower Oligocene. However, as Vaughan (1924, p.704) pointed out, it must be borne in mind that the boundaries between the major divisions of the Tertiary in Europe are not firmly drawn anywhere. The upper boundary of the Eocene as drawn in this country has been altered from time to time. The solution may well depend on the evidence obtained by the revision of other faunal groups and an accurate correlation with contemporaneous beds in Europe based on these revised studies.

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