Prof. Lamplugh, with the author's compliments.

On the Beds at the Base of the Ypresian (London Clay in the Anglo-Franco-Belgian Basin.

BY

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ON THE BEDS AT THE BASE OF THE YPRESIAN (LONDON CLAY) IN THE ANGLO-FRANCO-BELGIAN BASIN.

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PLATES 2 AND 3.

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I. INTRODUCTION.

Some apology is needed from any one who ventures to add to the already alarming bulk of the literature of English Tertiary geology. In reading through this literature, however, one cannot help being struck by the comparative rarity of papers which deal with the English and Continental areas as a whole. Since the work of Lyell and of Prestwich (40, 41, 42)* there have been some valuable papers—as for example, Harris and Burrows (144), but in recent years there does not seem to have been an equivalent amount of progress on this side of the Channel when compared with the great advances made in the study of Tertiary geology on the Continent.† The result is that the bulk of our work is confusing to Continental geologists, and there has been some uncertainty in the application of our English terms. For example, in Belgium and Northern France, a thin pebble-bed occurs at the base of the London Clay. Since the studies of Dollfus (133) in 1877 and Delvaux (95) in 1891, the majority of geologists have referred to these pebbles as "galets de Oldhaven," —see also Briquet (86) 1906, and (87) 1909—using the term "Oldhaven" or "Blackheath" Beds as synonymous with the Basement Bed of the London Clay, and ignoring the occurrence of a pebble bed at the base of the London Clay in England quite

*Numbers in parentheses refer to the Bibliography, p. 101.

†Fortunately this is not true of the Uppermost Tertiary, so admirably studied by Dr. F. W. Harmer.

separate from the Oldhaven Beds. On the other hand, certain Continental geologists (e.g. Van den Broeck (123)' 1899), having examined the Basement Bed of the London Clay in England, formed the opinion that the Oldhaven Beds do not exist in Belgium.

Again, Continental geologists, having formed an idea of the conditions under which their Tertiary deposits were formed, have attempted to bring our English series into harmony by proposing divisions differing widely from those accepted here. For example, our Bracklesham Beds have been separated into a lower division corresponding to part of the Continental Lutetian (Bruxellian) and an upper division corresponding to the Ledian (Auversian), or again, the Headon Beds have been united with the Barton Beds as Eocene (" Marinesian " or " Bartonian ") (138).

With the object of obtaining a connected idea of the Eocene deposits in the Anglo-Franco-Belgian region, I have spent the last two years studying these strata in Belgium, Northern France and the Paris Basin. The area is a perfectly natural one, since the four so-called " basins " are part of a single basin of deposition which has a common history. Speaking generally, there was a large partly-enclosed sea into which sediment was poured from two main sources ; a great eastward flowing river in England and a great northerly or north-westerly flowing river in the Paris Basin. The following paper is an attempt to correlate part of one series of Tertiary strata throughout the area mentioned.

II. ENGLAND.—THE LONDON BASIN.

The beds of this area are so familiar to English geologists and especially to members of the Geologists' Association, that it will only be necessary to outline, for the sake of completeness, their general characters.

Generalized Succession in the London Basin.

	Western and Northern Parts.	Central Part (East Surrey and West Kent).	Eastern Part. (East Kent).
Ypresian	London Clay	London Clay	London Clay
	Basement Bed, London Clay	Basement Bed, London Clay	[Basement Bed, London Clay]
	———	Oldhaven (Blackheath) Beds Pebbly (Blackheath) type	Oldhaven (Blackheath) Beds Sandy (Oldhaven) type.
Landenian	Woolwich and Reading Beds	Woolwich and Reading Beds	Woolwich and Reading Beds
	Fluviatile (Reading) type	Estuarine (Woolwich) type	Marine type
	———	Thanet Sands	Thanet Sands

Over the greater part of the Basin, there is a sandy, glauconitic, marine Bottom-Bed to the Woolwich and Reading Series.

In order to trace the changes in the strata immediately below the London Clay, a number of sections along the London Basin, starting from the extreme west, may be considered.

(1.) PEBBLE HILL, KINTBURY (Prestwich 38 p. 258 and White 75 p. 59).

In the extreme west of the London Basin the London Clay is only 15 to 20 feet thick. This westward attenuation is mainly original, but is probably accentuated to some extent by pre-Bagshot erosion (75 p. 69 and 54).

At Kintbury the succession is :—

		Metres.	Feet.
London Clay	Tough, brownish clay, with some small scattered flint pebbles in the lower part, passing down into Brownish sandy clay and hard clay (" argilite ")	2.10	7
Basement Bed, London Clay ..	Ferruginous sand or clay-ironstone with irregularly arranged pebbles, mostly of flint and up to 12 in. in largest diameter, together with some rolled chalk fragments ..	1.50	4–5
Reading Beds	Mottled clays and irregular sands	15.00	50

Elsewhere in the district the Basement Bed is fossiliferous, and is seen to be essentially a marine horizon.

(2.) HOLLINGTON BRICKWORKS, N.W. of Highclere (Jukes-Browne 27 p. 40 ; White 74 p. 394).

Here it is difficult to separate the London Clay from the Reading Beds, as they both consist of dark, sandy clays. Near the junction is a thin band of flint pebbles. These are mostly small, though some seen during a recent visit measured up to 9 inches in length, but still well rounded.

(3.) UP NATELY, 4 miles East of Basingstoke (White 76 p. 55).

In a brickyard just north of the canal a section exhibited (January, 1920) the following succession :—

		Metres.	Feet.
London Clay	Brownish clay, slightly sandy ..	5.00	16
Basement Bed, London Clay ..	Layer of tabular septaria, with fossils (*Ditrupa*, etc.) .. .. Very clayey sand with streaks of clay and beds of shells. The matrix of the shelly beds is practically pure glauconite .. A more clayey layer with a few small flints at the base	1.80	6
Reading Beds	Sand, slightly clayey, appears disturbed towards the top..seen for	1.80	6

The Basement Bed of the London Clay is here far more fossiliferous than previous observers seem to have noted, and is again essentially a marine horizon.

In the brickyard in the southern part of Hang Wood, 400 yards east of the last, a band of flint pebbles may be seen in the main mass of the London Clay. This is not an unusual feature in the western part of the London Basin.

(4.) READING (Prestwich 38 p. 266 ; Blake 5 p. 39).

The section formerly exposed in the Sonning Cutting, two miles east of Reading, may be quoted as a typical example of the succession in the district :—

		Metres.	Feet.
London Clay	Brown clay with septaria..seen for	4.30	15
Basement Bed, London Clay ..	Brown clay with subordinate and irregular layers of yellow sand, the whole mixed with the seams and patches of greensand and with some well-rounded flint pebbles. Irregular layers and masses cemented by carbonate of lime and full of well-preserved shells are of common occurrence	1.50	4–5
Reading Beds	Mottled clays, etc. .. about	20.00	66

The fossils of the Basement Bed are, as usual, all marine.

(5.) CHEAM, SURREY. (Whitaker 70 p. 245).

Here the London Clay has an oyster-bed at the base, and rests on Reading Beds.

(6.) CROYDON. (Klaassen 32 ; Whitaker 65 p. 216).

A magnificent section was formerly exposed in the railway-cutting through Park Hill, Croydon.

Although a few miles to the west they are entirely absent, the Oldhaven (Blackheath) Pebble Beds are here nearly 40 feet thick, with the top not seen. They are fossiliferous, and yield the usual mixed estuarine and marine fauna ; and they rest on Woolwich Shell beds with estuarine and fluviatile fossils.

Near West Croydon Station, and also near Thornton Heath Station, the London Clay, with a thin clayey pebble bed at the base, rests on Oldhaven Sands.

(7.) SHIRLEY (Davies 15).

Some interesting sections occur in the woods east of Shirley Village. They were recently visited by the Association (June 1920). One section showed alternating bands of clean, well-washed sands, clay beds and pebble beds. The arrangement of the beds can only be explained by the sorting action of strong currents. Another section exhibited current-bedded layers of

very coarse pebble beds alternating with pale coloured sands. Some of the pebbles measured 10 × 6 × 4 inches, but all were well rounded, and only occasionally could portions of the original cortex of the flint be seen.

(8.) ELMSTEAD, KENT (Whitaker 65 ; Holmes 22, 23 ; Stamp 53).

In the cutting at the northern end of Elmstead (Sundridge) Tunnel (S. E. &. C. Railway) the London Clay has a one-foot pebble bed at the base, resting fairly evenly on light coloured sands which contain lenticular masses of pebbles (Oldhaven Beds). The latter beds are about 10 feet thick, and rest on Woolwich shelly clays with freshwater fossils (*Paludina* and *Unio*).

At the southern end of the tunnel the Oldhaven Beds have thickened very greatly, consisting of over 40 feet of pebbly sands, and have " scooped down into " (*ravined*) the Woolwich Beds, so that they rest on the green Bottom Bed of the latter series. The tunnel was largely cut in the Oldhaven Beds, which here yield a large series of well-preserved fossils, especially the variable *Axinæa plumstediensis*. Lenticular oyster beds and hardened masses occur and are well seen in a neighbouring pit, just to the south-east of Elmstead Station, known in geological literature as the Sundridge Rock-pit.

(9.) KIDBROOKE AND ELTHAM PARK (Holmes 21 p. 153).

A very instructive section was formerly exposed in the railway cuttings from Blackheath through Kidbrooke to Eltham Park. As usual, the Blackheath Beds rest irregularly on different members of the Woolwich Series, but at the same time the Basement Bed of the London Clay—the usual clayey pebble bed—rests at Kidbrooke (Blackheath Park) on the Blackheath Beds, but at Eltham Park has overstepped the latter and rests on Woolwich Beds. This may be due to erosion of the Blackheath Beds prior to the deposition of the Basement Bed, or it may be due to local non-deposition of the former. In any case, it illustrate sclearly the stratigraphical distinction between the Blackheath Beds and the true Basement Bed of the London Clay. The two horizons are, of course, quite distinct faunally —the Blackheath Beds, with their mixed estuarine and marine molluscs, and the Basement Bed with a typically marine fauna.

(10.) CHARLTON (Whitaker 65).

Here is the famous section showing thick Blackheath Pebble Beds with fossiliferous sandy patches resting with slight irregularity on Woolwich Beds. The latter are more complete than usual, and show the highest division, consisting of laminated sandy clays (=leaf-bed of Lewisham). The present pit,

situated immediately to the south of the entrance to the railway tunnel, about half a mile east of Charlton Station, is not the one originally described, but the section is very similar.

(11.) ERITH (Whitaker 65).

Large ballast pit west of the station. In one part (the southern part) of this pit the Woolwich shelly clays are present, but to the north they have been eroded away, and the Blackheath Pebble Beds rest on a lower horizon. The latter are here very interesting, exhibiting false-bedding on a very large scale. The "false dip" is to the east; in the Bexley Heath railway cutting (Stamp 52) it is to the west; at Elmstead to the north (53); whilst at Blackheath the "false dips" of the beds are said to be in all directions (12).

(12.) SWANSCOMBE (Stamp and Priest 55).

To the south of the River Thames, between Dartford and Gravesend, there are several outliers of Lower Eocene beds. One of these—the Swanscombe Outlier—has recently been described in these Proceedings. The Blackheath Beds are particularly interesting in that the upper part yields a typically marine fauna very little different from that of the London Clay Basement Bed above, whilst at a lower level the typical mixed fauna is found. An exposure in the lower part of the Swanscombe Clay-pit showed the following sections :—

		Metres.	Feet.
Basement Bed, London Clay ..	Very sandy clay (the sand is very fine) with a few small well-rounded flint pebbles, especially in the lower part. A few scattered fragile shells, becoming very abundant at the base, where they occur in little lenticular seams of almost pure glauconite. This shell bed is, in places, cemented into hard blocks crowded with fossils (up to 15ins. thick)	1.50	5.0
	Band of brownish clay, hardened in places, with few or no fossils. Rests with a sharply marked junction on the bed below	.07–.15	3′–6″
Blackheath Beds ..	Pebble bed of well rounded black flint pebbles, up to 9 inches in length, in a matrix of rather fine, light-coloured sand, crowded with fragile shells	.51	1′ 8″
	Band of tough brownish clay ..	.07	3″
	Sand, pale yellowish and "clean," no fossils seen in lower part, but becoming pebbly and fossiliferous in the upper part, seen for	.60	2′ 0″

In this and in neighbouring outliers the Blackheath Beds rest in eroded hollows or "scoops" in the underlying beds.

Frequently the Woolwich Shell Beds are entirely removed and the Blackheath Beds may even rest on the Thanet Sands.

13.) UPNOR, KENT (Whitaker 62 p. 144).

			Metres.	Feet.
Basement Bed] London Clay.	..	Brown clay with septaria, more laminated in lower part and with a few scattered flint pebbles. Rests somewhat irregularly on the bed below .. seen for	1.20	4
Oldhaven Beds.	..	Sand, pale buff, with scattered pebbles, fossiliferous and with a sandy fossiliferous pebble bed at the base (1–1½ feet) ..	1.20–2.40	4-8
Woolwich Beds.	..	Pale-coloured sand .. .. Shell Beds, etc.	4.50	15

This section is still visible. The Blackheath Beds of Upnor contain an interesting series of fossils. Some forms do not seem to occur elsewhere, and several have been given specific rank by Edwards (MSS.) They appear, however, to be mutations of well-known species, probably due to the influence of the more marine conditions which prevailed to the east.

(14.) HERNE BAY (Reculvers) (Whitaker 62 p. 170; Gardner 19).

At the famous cliff-section near the "Oldhaven Gap" (or "Bishopstone Ravine") from which the name Oldhaven was taken, the following sequence is to be noted :—

			Metres.	Feet.
London Clay	..	Stiff bluish clay. At the base a few tiny flint pebbles may be found by searching. The junction with the beds below is fairly regular, but there is evidence of close affinity, streaks of clay occurring in the Oldhaven Beds		
Oldhaven Beds	..	Very fine brownish ("gris-fauve") sand, sometimes false-bedded, with some hardened tabular masses yielding the typical marine Oldhaven fauna ..	6.00	20
		Pebble bed, well rounded flint pebbles .. .. .. up to	.45	1½
Woolwich Beds	..	Glauconitic sand, fairly coarse, with marine fossils		

The occurrence of tiny pebbles at the base of the London Clay is interesting. There can be very little doubt that these represent the pebbly Basement Bed of the London Clay further west, and that their rarity is due to increased distance from source of origin. The very fine-grained character of the Oldhaven sands, as well as their colour and the occurrence of little lenticular streaks of clay, accord so well with the beds at the base of the Ypresian clay in North France and Belgium, as to suggest their

correlation. If that view is correct, then the Blackheath Pebble Beds, already reduced to a thin bed of pebbles in East Kent, are represented farther east by a mere line of pebbles, whilst the true Basement Bed of the London Clay does not exist in East Kent and Belgium.

(15.) South Essex (Whitaker 72, 73).

Passing northward, it is necessary to rely on well-sections for our knowledge of the sequence of beds under the great London Clay mass of Essex. In these sections it is usually possible to identify the Woolwich Shell Beds when present, and very frequently pebble beds or beds of pebbly sand are found between them and the overlying London Clay. But whether these beds are Oldhaven Beds or belong to the Basement Bed of the London Clay it is impossible to decide on the published evidence.

(16.) Harefield, Middlesex.

Turning now to the northern border of the London Basin, a good section of the base of the London Clay resting on Reading Beds (fluviatile type), is seen at Harefield.

The Basement Bed of the London Clay consists of about 5 feet of very sandy clay, with a thin pebble bed a short distance from the base, passing up gradually into typical London Clay. It rests with a sharply marked but regular junction on mottled clays of the Reading Beds. The Basement Bed is very fossiliferous, and, as we saw further west in the London Basin where the London Clay rests on the Reading type of Upper Landenian, the fossils are all marine.

(17.) Watford Heath Kiln, Bushey (Whitaker 65 p. 202).

This section only differs from that at Harefield in that there is a double pebble bed in the Basement Bed of the London Clay (which has the same marine fossils) and it rests on coarse sands of the Reading Series.

Other sections, too numerous to mention, along the northern border of the London Basin, show very similar characters (see 24, 25, 30, 31, 38, 51, 62, 63, 64 and 65).

(18.) Ipswich.

The sections in this district have been recently described in detail by Boswell (7).

Between the London Clay and the fluviatile Reading Beds, there is sometimes a sandy pebble bed. Whether this bed is regarded as part of the Basement Bed of the London Clay or as the equivalent of the Herne Bay type of Oldhaven Beds, it has a purely marine fauna. This is exactly as one would expect from observations in other parts of the basin ; when the Wool-

wich estuarine beds are absent, the succeeding fauna is a marine one, and the mixed Blackheath fauna is absent.

Together with the references cited in the Bibliography, sufficient has now been said to permit some general observations on the Oldhaven Beds and the Basement Bed of the London Clay.

1. The Woolwich and Reading Series (Upper Landenian).

In the London Basin, westward of a line passing north and south through the west of London (see map, fig. 12), these beds consist of a fairly constant marine bottom-bed, succeeded by gravels, current-bedded sands or mottled clays of freshwater or fluviatile origin. This is the Reading type of Upper Landenian. Along the northern outcrop the aspect is similar, except that the marine bottom-bed is far less constant. There is much evidence to show that the mass of sediment of the Reading Beds was deposited by a large river draining from the west and by tributary streams from the north-west (see map, plate 3). Frequently to the north-west (as at Harefield) the base of the Reading Beds consists of gravel indistinguishable from ordinary river gravels and occupying channels cut into the chalk (compare Hampshire Basin—44, 45, 50).

In the central region, occupying the eastern half of London, from Croydon eastwards into Kent as far as Sittingbourne, and stretching northward under a large part of Essex, the Upper Landenian commences with the same marine bottom-bed of glauconitic sand, but this is succeeded by well-bedded dark clays full of brackish-water shells (Woolwich type of Upper Landenian). The persistence over a wide area, the undisturbed bedding, and the homogeneous nature of the clay, point unmistakably to deposition in a well-sheltered estuary, or almost a lagoon. It was into this lagoon-estuary that the Reading rivers drained. As shown on the sketch-map (fig. 12) the Reading type (mottled clays) and Woolwich type (shell beds) are interbedded over a very considerable area, thus proving the absolute synchronism of the beds. On the whole, especially in the southern part of the area, the shell beds occur above the mottled clay; to the north the order is more variable. As one would expect, from the presence of a marine bottom bed, succeeded by brackish water clays, we have an indication of a "silting up" of the lagoon. This is still more apparent when the "striped loams" overlie the shell beds. These loams are clayey sands full of fragmentary plant remains. This is the horizon also of the "*Paludina* Beds" of Peckham, New Cross, etc. (*i.e.*, *freshwater* clays) and the famous "leaf-beds" of Lewisham. For the most part these higher loams were removed during a succeeding period of erosion of which we shall speak shortly. Again too, as one would expect, the *Paludina* Beds occur near the margin

of the estuarine area, towards the pre-existing freshwater regions of the mottled clays. Freshwater fossils are, however, by no means restricted to this horizon. They occur lower in the Woolwich shell beds, but are always more common towards the western margin of the latter.

Continuing eastwards, the estuarine facies passes very gradually to the marine type of Upper Landenian—fossiliferous sands—seen round Herne Bay. This gradual passage in a seaward direction again points to the tranquil conditions that prevailed during the Upper Landenian period and the absence of the disturbed conditions that we associate with a seaward delta. The fauna of the marine type of Woolwich Beds, like that of the Woolwich Bottom Bed further west, is that of the Sables-de Bracheux and Châlons-sur-Vesle in France—that is of the highest zone (Zone of *Cyprina scutellaria*) of the Lower Landenian.

2. The Oldhaven (Blackheath) Beds.

These beds consist of masses of extremely well rounded flint pebbles, of small size, in a sandy matrix (Blackheath type) or of beds of whitish or brownish sand with scattered pebbles, or bands of pebbles (Oldhaven type), passing to a single bed of sand with a basal bed of pebbles at Oldhaven itself. Only very rarely does one find pebbles other than of flint. The exceptions are flattened pebbles of "quartzite" (see below, p. 69).

The beds are fossiliferous in many places and the fauna is a mixed one, consisting essentially of both estuarine and marine forms (see below, p. 97). The proportion of the two elements in the fauna varies greatly from place to place. The beds are found stretching from East Kent (where, like the underlying

EXPLANATION OF FIGURE 12.

Blackheath Beds (Ypresian)
- φ = Blackheath Pebble Beds absent
- P = Blackheath Pebble Beds
- f = Fossiliferous localities

Woolwich and Reading Beds (Upper Landenian)
- M = Reading Mottled Clay (freshwater)
- S = Woolwich Shell-beds (estuarine)
- WF = Woolwich Freshwater Beds (with *Paludina*, etc.)

ω = Blackheath Beds resting unconformably on Chalk.

ωT = Blackheath Beds resting unconformably on Thanet Sands.

▭ ▭ ▭ = Approximate western boundary of the Woolwich Estuarine clays—i.e. the estuarine lagoons occupied the area to the east of this line.

▭o▭▭ = Approximate eastern limit of the Reading Mottled Clays (freshwater beds).
Between these two lines the Woolwich Shell Beds and the Reading Mottled Clays occur interbedded.

●●●●●● = Approximate western limit of the Blackheath Pebble-Beds.

– – – – – – – = Boundary of the Tertiary Beds (resting on Chalk).

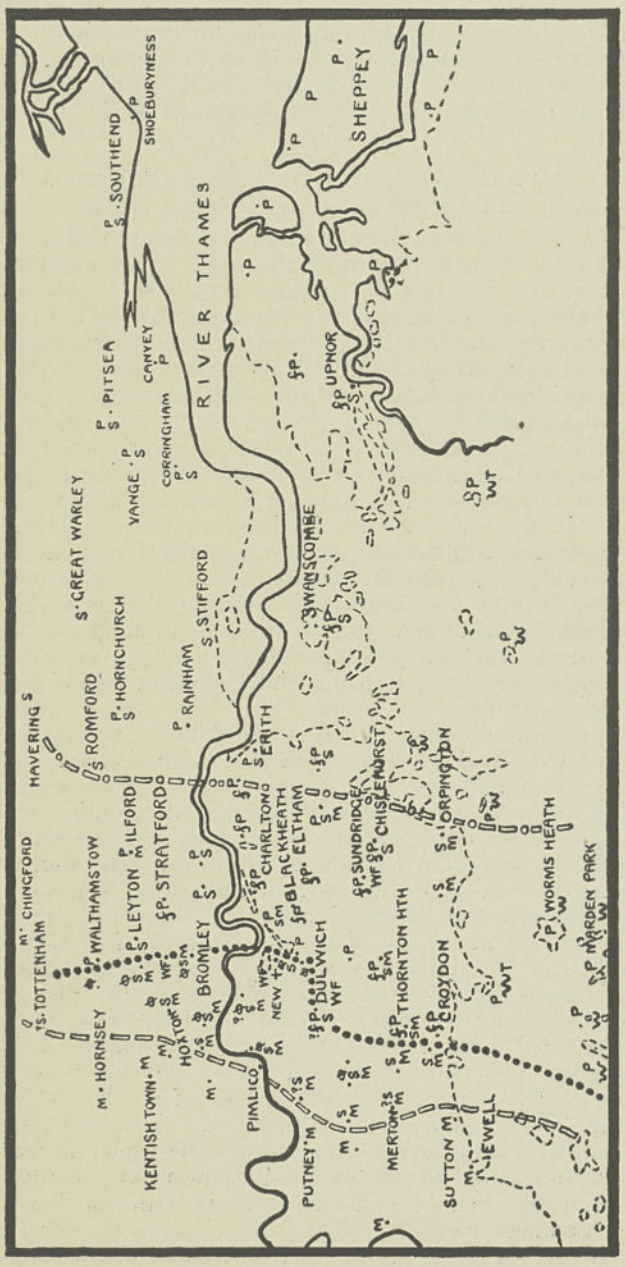

FIG. 12.—SKETCH-MAP OF PART OF THE LONDON DISTRICT, SHOWING THE DISTRIBUTION OF THE BLACKHEATH BEDS AND THE WOOLWICH ESTUARINE SHELL-BEDS.—*For explanation see page 66.*

Landenian the beds are truly marine) as far westwards as Croydon, and they probably underlie a part of Essex (see map, fig.12). In well-borings it is extremely difficult, as stated above, to separate the Blackheath Beds from the pebbly Basement Bed of the London Clay.

3. The Relation Between the Oldhaven (Blackheath) Beds and the Woolwich and Reading Beds.

This relation has always been a matter of great doubt.

Mr. Whitaker, when he first used the term Oldhaven Beds (60) recognized that they could be separated from the Woolwich and Reading Beds below and also from the Basement Bed of the London Clay above, and could therefore be separately mapped. I think I am correct in stating that he has always preserved an attitude of most laudable neutrality as to their affiniti s with the beds below or above (60 p. 413, 65 p. 235).

The attitude of the officers of the Geological Survey within recent years has varied considerably. As recently as 1902, Mr. Clement Reid compared an overlap of the London Clay in Hampshire with the well-known overlap on the North Downs " where Oldhaven Beds (the pebble beds at the base of the London Clay) occasionally rest directly on the Chalk." This would seem to imply that he considered the Blackheath Beds as the basal bed of the London Clay. On the other hand Mr. C. E. N. Bromehead, in revising the London District, has expressed the opinion that th: Woolwich, Reading and Oldhaven Beds form one Series (83.)

Mr. Bromehead recently suggested the following mode of formation for the Blackheath Beds in the discussion on Mr. Whitaker's paper on Worms Heath (72). He said, with reference to the Blackheath Pebble Beds, " Horizontally they appeared to form a great crescent made up of individual crescentic banks of pebbles, somewhat resembling a series of sand dunes. The crescents are convex to the east. On this outer side were the marine Oldhaven Beds, on the inner western side the Reading Beds. Immediately in the lee of the crescents the freshwater bed of the Woolwich Series was found, suggesting the formation of freshwater lagoons protected from the sea by the pebble ridges. In the vertical sequence he did not think that they marked a definite horizon, but were contemporaneous with various members of the Tertiary sequence. At the type-locality the Blackheath Beds occur almost at the base of the Woolwich and Reading Series, only the ' Bottom-Bed ' being present beneath them, whereas at other points nearly the whole normal sequence was found and the Pebble Beds come in at the top ; locally they might even be contemporaneous with the lower part of the London Clay."

Before passing on to a consideration of deposits of the same

type and relationships on the Continent, we will make a few remarks on the aspects of the subject in the London Basin.

(i.) The sketch map (fig. 12), shows the distribution of the Woolwich Beds (estuarine type), and of the Oldhaven (Blackheath) Beds. The more important fossiliferous exposures of the latter are indicated. One may notice—

(a.) The horizontal distribution of the Blackheath Beds corresponds almost exactly with that of the Woolwich shelly clays, though the area occupied by the former is somewhat less extensive. In other words the latter are, in most localities, succeeded either directly or with the intervention of the striped loams, by the Blackheath Beds. The two cannot, in the majority of cases, be contemporaneous.

(b.) The overlap of the Blackheath Beds to the south. The number of Blackheath outliers either on the dip slope of the North Downs or let down into pipes, and the absence of Woolwich Beds similarly let down into pipes, convince me that the overlap is a true one and not due simply to very pronounced "scooping" as Leach (34) has suggested.

(ii.) As Prestwich (39) showed many years ago, and as we have stated above, the contemporaneity of the mottled clays (Reading type) and the shelly clays (Woolwich type) cannot be doubted. Over a considerable area (as shown on fig. 12), the two types are frequently interbedded, but in the majority of cases the shell beds rest on the mottled clays.* This indicates that the mottled clays cannot be younger than the Woolwich shell beds and hence are older than the Blackheath Beds.

(iii.) Whilst it is well-known that the Oldhaven (Blackheath) Beds "scoop down" into the underlying beds and rest on any horizon from the Chalk to the top of the Woolwich Beds, I have nowhere seen clear evidence of a passage between undoubted Blackheath Beds and the various members of the Woolwich Beds. There is always a well-marked line between the two—a strongly defined "ravinement." This can only be explained, in the writer's opinion, by a pre-Oldhaven erosion of the underlying beds.

(iv.) Other evidence of this Pre-Oldhaven Erosion.

(a.) The "quartzite-pebbles" occasionally found in the Blackheath Beds have been identified by my friend, Mr. H. A. Baker (1) with the siliceous concretions or "sarsens" of the Woolwich and Reading Beds. These sarsens, although only occasionally seen *in situ* in this country, are everywhere characteristic of the same horizon in Belgium, North France and the Paris Basin. Just as

*In one area the shell beds seem to have extended much further to the west. This is possibly indicated by the most westerly occurrence of *Cyrena*, etc., recorded (as far as the writer is aware) by Prestwich (39) and later writers near Guildford.

the Reading Sands vary in coarseness, so do the sarsens vary in texture. Thus petrologically the quartzite pebbles of the Blackheath Beds may differ, as Mr. A. J. Bull has said (discussion on Mr. Whitaker's paper 72) from some specimens of Sarsen; but on the other hand Mr. Baker and I are agreed on their being absolutely indistinguishable from other specimens of sarsen—e.g., some of the non-pebbly parts of the Hertfordshire puddingstone. I shall show later that precisely similar pebbles occur in the equivalent beds in North France.

(b.) The heavy detrital minerals of the Blackheath Beds are practically identical with those in the underlying beds, but are frequently sorted out into streaks of surprising richness (Boswell 7, Stamp 53). This is exactly what one would expect in the erosion of the underlying beds and redeposition of material. The character of the sands also points to sorting by current-action. The "well washed" character of the sands and the separation of the argillaceous material into separate bands can be easily explained in this way.

(v.) With regard to the suggestion that the Freshwater Bed of the Woolwich Series occupies the lee side of the Blackheath Pebble Banks and was formed in a freshwater lagoon thus protected from the sea, I would point out that

(a.) This *Paludina* bed occupies a position approaching the fringe of the brackish water lagoons of the Woolwich Shell Beds, in a position analogous to the tracts of freshwater marsh bordering the estuarine flats of modern rivers. Somewhat similar freshwater beds, but more extensively developed, occur round the Upper Landenian estuarine areas of the Paris Basin, e.g., at Rilly near Reims. Moreover, freshwater shells occur at lower levels in the Woolwich Beds of South London.

(b.) The position of this bed, generally above the shelly clays and on the same horizon as the leaf-beds, is consistent with the silting up of the Woolwich lagoon-estuary.

(c.) Most observers (Whitaker 60 p. 415, 62 p. 240, Young 82 p. 257) have agreed that the character of the Blackheath Pebbles is entirely inconsistent with a coastal (beach) or sub-aerial origin. The absence of any bleaching or inclusion of imperfectly rounded pebbles, is unlike any beach, deltaic shoal or bar at the present day and can only be explained by supposing these pebble beds to be of submarine formation. The perfect rounding of the pebbles points, then, to continual movement in submarine shoals some distance from land.

(vi.) Whatever the exact age of the deposits they frequently have the appearance of having been piled up by seas rushing in

from the east, as shown by the crescentic arrangements referred to by Mr. Bromehead and by the false bedding on a large scale seen at Erith and elsewhere. This need not imply that they were piled up above the level of the sea, but in completely submerged banks.

4. The Conditions of Formation of the Oldhaven-Blackheath Beds.

Bearing in mind all the above points, it is possible to outline the events that would give rise to the Oldhaven Beds.

(i.) In Upper Landenian (Woolwich) times a broad, shallow lagoon-like estuary existed, passing gently to a seaward phase on the east.

(ii.) If a slight earth movement caused a sinking of such an area, the sea would rush in from the east and spread very rapidly over the whole of the estuarine flat. It would give rise to an area of disturbed conditions, of irregular currents cutting down into the soft beds below, and submarine shoals. The sea would bring with it a marine fauna which would be mixed with the existing estuarine species, and for a time the two would continue to exist together, the marine fauna gradually becoming predominant. This is precisely what we find, both stratigraphically and palæontologically, in the Oldhaven-Blackheath beds.*

This view of the sequence of events is in accordance with the usual cycle of deposition as outlined by Prof. W. W. Watts in his Presidential address to the Geological Society in 1911 (58). Remembering that from the Upper Landenian to the Ypresian (London Clay) we have obviously a subsiding coast, we may apply his words, "The rising coast will be one of sea flats and deltas, the subsiding coast one of gulfs and estuaries" and "planes of lacustrine . . . deposition will be the first to receive new sediments."

The earth-movement in the London Basin seems to have been most pronounced along the southern border. It is there that the Blackheath Beds show their characteristic features. There is strong evidence for connecting this movement with the intermittent uplift of the Weald as Prestwich (39) and Whitaker (62) suggested long ago. It is not possible to deal in detail with this question here, but in passing one may note :—

(a.) The Wealden uplift possibly commenced before the end of the Cretaceous (see e.g., Baker and Priest 2). The zones of the Upper Chalk are found to decrease in thickness as one approaches the Wealden area.

(b.) The prolongation of the Weald on the French side

* Mr. G. M. Davies (13) has already realized that the presence of a flat platform must have been necessary for the accumulation of the Blackheath Pebble-Beds. His idea, however, seems to be that of a coastal flat, such as Dungeness, or a shoal within the limits of wave-action.

of the Channel had been formed and in part denuded in pre-Eocene times, as we find Thanet Sands resting on Middle Chalk, or even on Lower Chalk in the Boulonnais (Gosselet 102). During the summer of 1920 I visited several of the outliers on the slopes of the downs surrounding the Bas-Boulonnais. Many of the outliers that appear on the present edition of the Carte Géologique de la France (1 : 320,000 sheet VIII. ; 1 : 80,000 sheet Boulogne) are certainly of the nature of pipes ; others seem to have been mapped on the evidence afforded by a group of " sarsen-stones " (" grès mamelonné ")—e.g. east of the Boulogne-Samer Road. Round the " ceinture " of the Bas-Boulonnais I was not able to find an undoubted outlier of Eocene beds, but when one follows along the axis of the Wealden uplift further east into Artois, one finds extensive tracts of Lower Eocene sands resting on low horizons of the Chalk. This is seen in some of the large outliers near Arras.

(c.) The Woolwich Series to the north of the North Downs commences with a thin pebble bed which points to a slight movement between the time of formation of the Thanet Sands and the marine Bottom-Bed of the Woolwich Series. The pebbles tend to become more numerous as one approaches the Wealden area, and, as Mr. Priest and I (55) have recently shown, at Swanscombe there is evidence of contemporaneous erosion. In a few places the Woolwich Beds seem to overstep the Thanet Sands to some extent, or the thickness of Thanet Sands between them and the Chalk is very small.

(d.) There is certainly an overlap of the Oldhaven Beds along the North Downs on to Thanet Sands or Chalk, e.g., at Worms Heath (71–72).

(e.) Rapid thinning of the London Clay in a southerly direction has been pointed out by Mr. Leach at Shooter's Hill (35).

(f.) The London Clay fossils from the Isle of Sheppey (especially the freshwater reptiles) seem to indicate proximity to land. The land could not have been near on the west, north, or east. (See Owen and Bell, Fossil Reptilia of the London Clay, *Mon. Pal. Soc.*, 1849-58).

(g.) In commenting on the absence of pre-Chalk elements in the Oldhaven pebbles, it is necessary to remember that a considerable thickness of Chalk—perhaps 500 to 1,000 feet—must have been denuded from the Wealden dome before the Greensand chert beds were exposed.

(h.) This denudation of the Wealden Chalk quite close to the southern border of the London Basin suggests a ready source for the material of the Blackheath Pebble

Beds. Jukes-Browne arrived at this conclusion (28). Possibly shingle beds were already forming on the Wealden dome in Landenian times.

It would seem, therefore, that the Wealden tract formed a large submerged shoal, or perhaps an island even before London Clay times. There was most probably a connection between the western end of the London Basin and the Hampshire Basin during the whole of the Eocene period, but further evidence is desirable on this question.

5. The Basement Bed of the London Clay (*sensu stricto*).

While the Oldhaven Beds were being formed under disturbed conditions consequent on the first irruption of the sea into the Upper Landenian lagoon, the sea continued to spread westwards over the Reading Beds, carrying with it a marine fauna. The latter included an occasional estuarine mollusc which had survived the incursions of the Blackheath Sea (*Cyrena*) and many shallow water *Cyprinæ* and *Cythereæ*. This further depression and westward transgression of the sea must have been an extremely gentle though rapid movement, there being very little sign of disturbed conditions in the Basement Bed of the London Clay in either the London or the Hampshire Basin, or of extensive erosion of the underlying Reading Beds (see White 80).

On the whole the material of the Basement Bed seems to have come from the west. In the extreme west of the London Basin the thin basal pebble bed includes pebbles up to 14 inches long ; in the neighbourhood of London the pebbles are practically indistinguishable from those of the Blackheath Beds ; in East Kent they are very small and so uncommon as to require searching for ; whilst in North France I have nowhere been able to find any. Around London, as Mr. Barrow (3) has pointed out, the distribution of the pebbles in the Basement Bed is irregular and may indicate current action (p. 3).

6. The Source of the Pebbles in the Lower Eocene Pebble Beds.

Summarizing the foregoing remarks, it is suggested that the bulk of the pebbles in the Blackheath Beds (as well as in the Woolwich Bottom Bed) were derived from the Wealden dome. Their remarkably well-rounded character is probably due to their having been partially rolled along the shores of the sea that surrounded the rising Wealden area during Lower Landenian times. Considerable rounding took place during transport from the Wealden area to the London syncline. The final rounding is due to continual agitation of the waters of the Blackheath sea during the deposition of the pebble beds. The conditions of formation of the Lower Eocene deposits is shown diagrammatically in fig. 13.

Throughout Eocene times, one must remember, there was a huge river flowing from the west, which brought down the bulk of the sediment of the Eocene beds. It seems probable that the pebbles in the Basement Bed of the London Clay were derived principally from this source, since the pebbles seem to decrease in number and size towards the east. (See Plate 3.).

III. BELGIUM AND NORTH FRANCE.

The generalized sequence of the Lower Eocene is as follows :—

North France. (Department du Nord, etc.)	Belgium. (Notation of the Geological Survey)	
Sable yprésien	Sable yprésien	Yd
Argile yprésienne (Argile des Flandres)	Argile yprésienne	Yc
Sand	Sand or sandy clay	Yb
Pebble Bed	Pebble Bed (local)	Ya
Upper Landenian	Upper Landenian	L2
Lower Landenian	Lower Landenian	L1

The Lower Landenian consists of marine sands (the lower part of the Sables d'Ostricourt of Gosselet) with some beds of clay (Argile de Louvil) and coherent marly or siliceous sands

EXPLANATION OF FIGURE 13.

Diagrams showing the effect of the successive uplifts of the Weald on the deposition of the Lower Eocene sediments.

Each of the four diagrams is an idealized section drawn from south (region of Wealden uplift) to north in the North-western Kent area.

(a) Conditions during the deposition of the Thanet Sands.—Note the southward passage of the Thanet Sands into shallower water or littoral conditions. Here one sees angular or partly-rolled flints, resulting from the marine denudation of the slightly uplifted Chalk of the Wealden anticline.

(b) Conditions during the deposition of the Woolwich Estuarine Shell Beds.—A slight movement of uplift in the south has caused a thin pebble bed to be formed between the Thanet Sands and the Woolwich Bottom Bed. This pebble bed decreases in thickness to the north. Then the shallow sea has become silted up owing to the deposition of the Woolwich shell beds, and its place taken by an estuarine lagoon.

(c) Conditions during the deposition of the Blackheath Beds.—Pronounced uplift in the south has caused the movement of great masses of pebbles towards the newly depressed region of the north. Note the unconformable relationship of these pebbles beds with the underlying strata, and their decrease in importance towards the north.

(d) Conditions during the deposition of the London Clay.—Continued depression has allowed the deposition of a thick mass of marine clay in comparatively tranquil deep-water conditions.

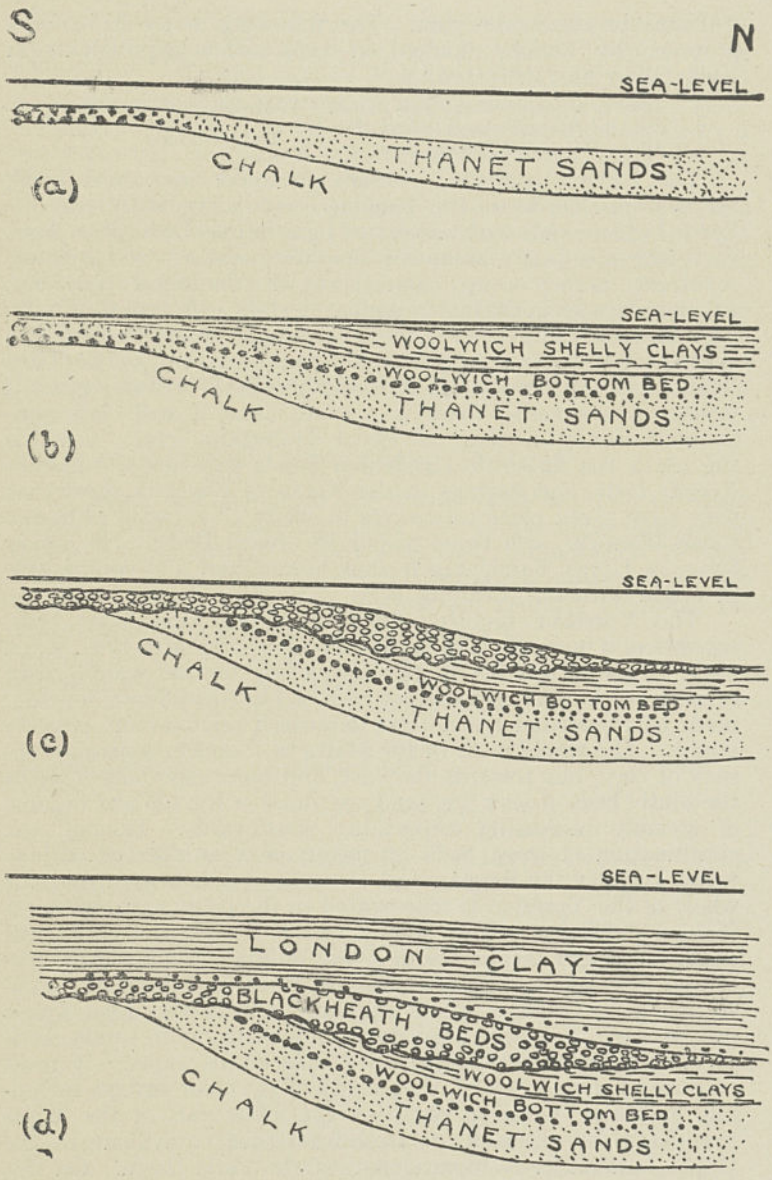

FIG. 13.—DIAGRAMS SHOWING THE EFFECT OF THE SUCCESSIVE UPLIFTS OF THE WEALD ON THE DEPOSITION OF THE LOWER EOCENE SEDIMENTS

For explanation see page 74.

(tuffeau) in the lower part. The following zones have been proposed by Leriche (quoted in 149). Their equivalents in England are also indicated :—

3.	Zone of *Cyprina scutellaria* Lamk.	Woolwich Bottom Bed.
2.	Zone of *Pholadomya Koninckı* Nyst.	Thanet Sands.
1.	Zone of *Cyprina Morrisi* Sow.	

The Upper Landenian consists wherever seen (i.e., along the southern border of the Belgian Tertiary region) of current-bedded white sands with associated lignitiferous beds, pipe clays, etc. These beds are obviously fluviatile, and are of very local occurrence as they occupy channels cut into the Lower Landenian or sometimes (as in the higher regions to the south) into the Chalk. The direction of these channels generally seems to be from the south-east (Stevens 122, Passau 114, Leriche 111). They thus appear to have drained from the Weald-Artois region of uplift. Occasionally there is a small area of stiff clay, presumably lacustrine (e.g., at Leval Trahegnies 120). Towards the north the fluviatile Landenian Sands pass under the later Eocene beds, and borings in the North of Flanders show that they have given place to a series of shelly clays, with estuarine fossils identical with those of our Woolwich Beds. The sandy facies of Upper Landenian is thus homotaxial and comparable in origin with our Reading Beds.

The Ypresian, ignoring for the moment the basal beds, consists of a mass of clay identical lithologically with the London Clay. This correlation is also borne out by the scanty fossil remains, and a recent discovery of a richly fossiliferous horizon, made by the author but not yet described, removes any possible doubt. The whole mass in the plains of Flanders generally consists of clay, but towards the east, and more especially towards the south, beds of very fine sand are found at the top and become of steadily increasing importance southwards. Tracing the continuation of these beds by means of a number of outliers which connect the Belgian and Paris Basins, it is seen that the whole of the Ypresian is represented in the latter basin by sands (Sables de Cuise). The homotaxy of the Argile yprésienne of Belgium and the Sables de Cuise of the Paris Basin is now established beyond doubt. Leriche (108) has described well-sections near Calais in which argillaceous beds with *Pholadomya margaritacea* (London Clay type) alternate with sandy beds yielding *Nummulites planulatus* (Cuise Sands type). It must be remembered, however, that many of the older writers, including Professor Gosselet, regarded the lower part of the Argile yprésienne as estuarine or freshwater and equivalent to the Upper Landenian (= Sparnacian) of the Paris Basin. On this hypothesis Gosselet divided the Argile yprésienne into a lower (unfossiliferous) Argile d'Orchies and an upper marine (fossiliferous) Argile de Roubaix. He was not, however, able to trace

a line of division between the two, and he himself admitted they were indistinguishable when not seen in contact with lower or higher beds. To the east in Belgium the whole mass of the Ypresian Clay thins and passes into a coarse glauconitic sand —clearly a marginal facies—as seen near Tirlemont (106) or a series of sands and clays—also of shallow water origin—as at Morlanwelz near Charleroi (89).

At the base of the Ypresian Clay there is usually a bed of sand —as a rule not less than one metre in thickness—and below that some pebbles, occasionally a thick pebble band but frequently only a very sparse layer.

I will now describe some typical sections in detail, not only because of their general interest, but also because several (those marked Stamp) are here described for the first time. Authorities for each section are quoted, but all these sections I have visited myself.

1. BLANC-NEZ near Calais (Briquet 87 and 88).

A short distance from the Chalk cliffs are two or three Tertiary outliers, forming small but conspicuous hills called "Les Noires Mottes." They owe their preservation to large masses of ironstone in sands of Diestian (Lenham Beds) age forming the summit. The eastern hill recently exhibited the following section in a trench :—

Diestian	Coarse iron-stained sands.	
Ypresian	Grey plastic clay.	
	Sand, with lenticles of clay.	
	Pebbles of black flint, perfectly rounded ("Galets de Oldhaven")	
Lower Landenian ..	Glauconitic sands.	
Chalk		

M. Briquet has also traced the "Oldhaven Pebbles" on the surface near Calais, marking the outcrop of the base of the London Clay.

2. PLATEAU DES BRUYÈRES, near Saint Omer (Stamp).* Sand pit 300 metres E.S.E. of the cemetery.

Quaternary	Surface soil and gravels	2.00 m.
Ypresian	Grey plastic clay	1.50 m.
	Sand, sandy clay and clay in lenticular bands	1.00 m.
	Sand, very fine, grey-brown (gris-fauve) ; lenticular band	0.40 m.
	Clayey sand with bands of clay ..	0.40 m.
	Layer of small sparse black flint pebbles and ? sarsen pebbles ..	
Lower Landenian ..	Greenish-white sand tending to be false-bedded and coarser towards top .. .. .. seen for	5.00 m.

3. WIZERNES, near Saint Omer (Stamp).

A sand pit 2 km. east of the village showed in October 1919 the following succession :—

Quaternary ..	Surface soil and gravels	1.00 m.
Ypresian ..	Massive grey-brown plastic clay ..	1.00 m.
	Clay with partings of sand, sometimes rather coarse, sometimes very fine	1.00 m.
	Sand, false-bedded, varying from very fine to somewhat coarse grey-brown (gris-fauve) in colour, contrasting strongly with sand below	1.00 m.
	Line of sparse well-rounded flint pebbles	
Lower Landenian ..	Sand, whitish in upper part and with numerous worm tubes, becoming green and very glauconitic in the lower part	8.00 m. +

4. CHOCQUES, near Béthune (Stamp).

Section in sand pit, August 1919 :—

Quaternary ..	Loess interbedded with gravels ..	1.00 m.
Ypresian ..	Dark grey clay	0.30 m.
	Extremely fine pale grey-brown sand	0.30 m.
	Brownish clayey sand, somewhat coarser	1.00 m.
	Line of small, well rounded flint pebbles and calcareous pebbles ..	
Lower Landenian ..	Whitish sand, fairly coarse, becoming greener and very glauconitic in the lower part	7.50 m. +

5. LABEUVRIÈRE near Béthune (Stamp).*

The large sand pit at the northern end of the Bois des Dames showed in August 1919 :—

Quaternary ..	Coarse gravel	1.50 m.
Ypresian ..	Dark grey clay	0.50 m.
	Brownish, coarsely sandy clay ..	0.30 m.
	Very fine pale grey sand	0–0.30 m.
	Brownish, coarsely sandy clay ..	0.20–0.80m.
	Line of pebbles including small black well-rolled flints, fragments of reddish sandstone and calcareous pebbles	
	Irregular junction.	
Lower Landenian ..	Whitish sand mixed with clayey material from beds above ..	0.20 m.
	Sand, greenish white, glauconitic, especially in lower part	20.00 m. +

6. WAHAGNIES, between Lille and Douai (Stamp).

Section seen in sand pit 300m. south of Church.

	Made ground	3.00 m.
Ypresian ..	Shaly clay with sand partings, a few plant remains	0.30 m.

	Brown sand, rather coarse with lenticles of grey clay	0.30 m.
	At the base a large number of calcareous pebbles	
Lower Landenian ..	Sand, greenish-white in upper part, becoming dark green and very clayey in lower part	4.50 m. +

There is a photograph of this section in Leriche (109). A very similar section is seen in a sand pit 1½ km. N.N.E. of Livercourt Station.* Here numerous tiny flint pebbles occur in the Basement Bed. In all the above sections, but especially at Wizernes and Wahagnies, there is a strong "ravinement" or irregular junction at the base of the Ypresian.

* Sections marked thus are described in less detail in Briquet (86) where notes on other exposures are given. M. Briquet emphasizes the grey-brown ("gris-fauve") colour and great fineness of parts of the basal sand in the whole of the above area. He mentions that Prof. Leriche was astounded, on visiting the Herne Bay section, by the lithological similarity of the Oldhaven Beds there. I can fully endorse Prof. Leriche's opinion ; the colour, the extreme fineness together with coarser patches, the occasional false-bedded structure, the lenticular streaks of grey clay all emphasize the great similarity.

It is extremely interesting to note the occurrence in this basal pebble bed of pebbles derived from hard beds in the underlying Landenian (see Briquet 86 p. 141). One can sometimes find "quartzite" pebbles formed from fragments of the "sarsens" of the Upper Landenian, thus presenting an exact analogy with the "quartzite" pebbles of our Blackheath Beds, which Mr. Baker (1) has recently shown are derived from Reading sarsens.†

Although the Upper Landenian fluviatile sands, owing to their very local occurrence, are not seen in any of the above sections, they are well exposed at many intervening points, e.g., at Beauvry (near Béthune) with "sarsens" (grès mamelonné) *in situ*, and at Montigny-en-Ostrevant.

7. Mont d'Eribut, near Mons (Cornet 90).

Here Ypresian clay, somewhat altered by circulating waters, and very slightly sandy at the base, rests directly on marine sands of Lower Landenian age. I could find no pebbles, and M. J. Heupgen of Mons tells me he has never seen any at the base of the Ypresian in the immediate neighbourhood of Mons. The characteristic Oldhaven pebbles, which had gradually been seen less abundantly as one progressed eastwards from Calais, are here absent. In the neighbourhood of Mons sandy

†In *Proc. Geol. Assoc.*, xxx., 1919, p. 204, I am erroneously quoted as stating that these pebbles occur in the "Sparnacian."

beds, often of considerable thickness, are frequent at the base of the Ypresian clay (e.g., see Cornet 91, 92).

8. MORLANWELZ, between Mons and Charleroi (Cornet and Briart 89 and Mourlon 112 p. 212).

Here one is approaching the eastern shore of the Ypresian sea and the whole deposit becomes altered in character and consists of beds of hard clay (argilite) and sand. The beds are fossiliferous and yield an interesting fauna, including *Leda Corneti* and *Nummulites planulatus*.

9. TIRLEMONT (East of Louvain) (Ledoux 106).

Quarry of Overlaer-lez-Tirlemont. This exposure is also near the eastern shore of the Ypresian sea (Rutot 117) and the Ypresian is represented by a small thickness of coarse glauconitic sandy clay, resting on fluviatile Upper Landenian sands. The latter have beds of quartzite (grès mamelonné = "sarsens," *in situ*) with well-preserved plant remains.

The last two localities illustrate very well the placid and tranquil conditions which prevailed along the eastern shore of the Ypresian sea—so different from conditions which prevailed in early Ypresian times in other directions.

10. BORINGS THROUGH LATER EOCENE STRATA IN NORTH-CENTRAL BELGIUM, from Louvain to Ostend.

In many of these the Ypresian Clay is shown to become very sandy in the lower part and well-marked pebble beds have been observed in numerous widely separated localities (Ostend, Ghent, Renaix, Hobecq, Beaurieux-Asnières, Dottignies-St. Leger, Alost and Amougnies). For details of occurrences known up to the year 1890 reference should be made to Delvaux (95), who also gives a bibliography of the subject. Other details may be found in Van Ertborn (96, 97, 98).

At Renaix the pebble beds are particularly well known and were formerly exposed at the surface.

The Bibliography of the present paper (p. 104-5) includes references to a few accounts of borings which have passed through the sandy base of the Ypresian Clay (Yb), but the list must not be taken in any way as exhaustive (93, 99, 103, 104, 112, 118).

In the Ypresian sea that covered Belgium there seem to have existed several islands, or rocky masses rising above the general level of the sea-bottom. Around these masses pebble beds of well-rolled local rocks are often well developed. Round the porphyrite mass of Quenast there is such a bed of rolled fragments of the igneous rock. It is overlain by Ypresian clay and is probably at least in part of Ypresian age, but may be pre-Ypresian Eocene (Leriche 110).

At Alost a boring proved a pebble bed consisting principally

of Palæozoic rocks (quartzites) with some of the normal flint pebbles. This is not surprising since the Palæozoic floor of Central and North-West Belgium is at no great depth (Rutot 116).

At Ostend the pebble beds rest on shelly clays of Woolwich type, yielding *Cyrena cuneiformis, Melania inquinata*, etc. (see Leriche 107).

IV. FRANCE—THE COAST OF THE ENGLISH CHANNEL.

As Prof. Leriche (156) has shown, the Ypresian sea was continuous in the so-called Belgian and Paris Basins, and extended also northwards from the latter area to the borders of the English Channel. Along the shores of the Channel are a number of outliers which can conveniently be considered now, as they form a connecting link with our Hampshire Basin.

The general succession is :—

Ypresian	Black flint pebbles (galets noirs).
Upper Landenian ..	Dark clays with estuarine shells, and *Unio* beds in the lower part.
Lower Landenian ..	Sables de Bracheux

1. ST. JOSSE-TEN-NOODE, South of Boulogne (Briquet 86).

At a brickyard 300 metres north-east of the station, the following section was visible in July 1919 :—

Ypresian	Black flint pebbles, perfectly rounded, of typical Blackheath type, with some sand—seen on crest of hill above brickyard	
Upper Landenian ..	Dark bedded clays, with estuarine shells—*Cyrena cuneiformis, C. cordata*, etc. A thick (1m.) bed of *Ostrea bellovacensis** occurs towards the upper part, sandy beds in the lower part .. seen for	6.50 m.

Greenish Landenian sands were formerly visible below. The resemblance of the shell-beds to our familiar deposits is most striking and remarkable.

In a brickyard at Saint-Aubin, about 1½km. south of the last, bands of soft claystone with freshwater shells (*Unio* cf. *Wateleti, Hydrobia* sp., etc.) are intercalated with the estuarine clays.

2. ST. VALERY-SUR-SOMME (at the mouth of the River Somme).

The conspicuous hill to the south-west of the town consists of Lower Landenian Sands, which are quarried in several places. Towards the top of the hill I found Woolwich shell-beds, of slightly more marine aspect than at St. Josse, with *Cyrena cuneiformis, Melania inquinata, Ostrea bellovacensis*, and *Mytilus* sp. On the slopes of the hill are numerous sarsens, apparently

See note p. 89

derived from the Woolwich Beds. Some rounded flint pebbles on the summit of the hill may represent the remains of the base of the Ypresian.

3. Dieppe.

The well-known Tertiary outliers to the west of this town have been described by several authors, whose accounts vary somewhat.

All are agreed as to the identity of the *Sparnacian* (Woolwich Beds), which are well developed. Above these a bed of very fine sand and an overlying grey clay have been referred by Whitaker (61) and Dollfus (132) to the Oldhaven Beds and London Clay respectively. Parent (161), however, having found a cast of *Cyrena*, in the supposed London Clay, includes it in the "Sparnacian." The succeeding quaternary gravel, however, contains well-rounded black flint pebbles of the usual Eocene type. I was unable, during a recent visit (July 1920), to obtain any further evidence as to the presence or otherwise of the Oldhaven Beds. The bed of fine sand may well represent the Basement Beds of the London Clay despite the absence of pebbles at the base.

V. ENGLAND—THE HAMPSHIRE BASIN.

From Dieppe in Normandy it is convenient to pass to the other shore of the English Channel, to the easternmost point of the Hampshire Basin at Newhaven.

In the Hampshire Basin the general succession is well known :—

	Main area.	Eastern Area (Newhaven).
Ypresian	London Clay.	London Clay.
	Basement Bed, London Clay.	Basement Bed, London Clay.
Upper Landenian	Freshwater or fluviatile beds. (Reading Type).	Estuarine Beds. (Woolwich Type.)
Lower Landenian	Possibly represented by basal marine sands. (=Zone of *Cyprina scutellaria*).	

1. Newhaven (Prestwich 39, Whitaker 61).

Here the London Clay, finely sandy in the lower part, with a basal pebble bed, rests on estuarine Woolwich Beds.

2. Main Area of the Hampshire Basin.

Sections showing the Basement Bed of the London Clay resting on the mottled clays or fluviatile sands of the Reading Series may be seen in several places—Whitecliff Bay (Isle of Wight), Alum Bay (Isle of Wight), Studland Bay (Dorset)—in the last locality generally obscured—and in various inland sections (see 9, 17, 37, 38, 47, 48, 49, 68, 78, 79, 80, 81).

In all these sections the London Clay is very sandy or has distinct beds of fine sand (often very glauconitic) towards the base. This basement bed is occasionally fossiliferous and the fossils are all marine, being species characterising the Basement Bed of the London Clay in the west of the London Basin. There is generally a thin pebble bed at the base, which sometimes swells into lenticular masses several feet in thickness—especially to the west—(46). But there is nowhere a bed with the mixed Blackheath fauna. This is exactly what we should expect if the hypothesis for the formation of the Blackheath Beds in the London Basin, already outlined, is correct, as the beds below are of Reading type. It may be argued that the Basement Bed is only occasionally fossiliferous, but where it is, the fossils are essentially those of the Basement Bed, and it is unreasonable to suppose the Blackheath fauna once existed in another part of the same bed. Then again, I can find no record for the pebble beds scooping down into the underlying sediments, but rather resting with but slight unconformity on them. This is a feature associated with the Basement Bed of the London Clay in the London Basin, but not with the Blackheath Beds. (White 80).

VI. FRANCE—THE PARIS BASIN.

The succession of the Lower Eocene Beds of the Paris "Basin" may be summarized as follows :—

Ypresian		Sables de Cuise. Sables de Sinceny.
Landenian	Upper	Argiles à Lignites and associated beds (estuarine and freshwater).
	Lower (marine)	Sables de Bracheux and Châlons-sur-Vesle. Tuffeau de la Fère.

The lowest zone (zone of *Cyprina Morrisi*) of the Lower (marine) Landenian is not represented in the Paris Basin. The Landenian sea reached the north-eastern part of the Basin at a later date, and deposited the Tuffeau de la Fère (zone of *Pholadomya Koninckı*). But over the greater part of the area the lowest Landenian deposits are of the age of the zone of *Cyprina scutellaria* and *Cucullæa bellovacensis* (Sables de Bracheux and Châlons-sur-Vesle). Locally towards the south and south-east there are beds of hard pale-coloured limestone—probably of freshwater origin—in the upper part of the Landenian sands (e.g., Calcaire de Mortemer, Calcaire de Sinceny, etc.). The Lower Landenian—the "Thanetian" of certain French authors—is succeeded by a series of clays with associated lignites.

and sands ("Sparnacian"* or Upper Landenian). These correspond both lithologically and palæontologically with our Woolwich and Reading Beds, and are quite as variable as in England. The Woolwich type of deposit—clays with estuarine shells—occurs principally in the central part of the Paris region, stretching as far north as the English Channel; whilst the Reading type occurs round the borders of the basin (see Plate 3). The fluviatile sands of this horizon are often seen to occur in channels cut in the marine Landenian or in the Chalk. In the extreme south-east, near Reims, the Landenian is represented by a freshwater limestone—the Calcaire de Rilly.

The Sables de Sinceny† are a variable group of beds, but generally consist of fairly coarse sands with abundant well rolled black flint pebbles. They are frequently fossiliferous or include lenticles of shelly débris ("falun"). Whilst sometimes reaching 9 metres in thickness, they do not generally exceed 4 metres, and are sometimes represented merely by a band of pebbles. They are not, however, by any means local beds, but are found over a very wide area (see Plate 3).

The Sables de Cuise‡ are a series of fossiliferous sands, generally very fine-grained, which correspond to the Ypresian Clay of Belgium and to the London Clay. It is interesting to note that there is generally a thin pebbly basement bed which is distinct from the pebbly Sables de Sinceny, just as the Basement Bed of the London Clay is distinct from the Blackheath Beds.

It is unnecessary here to enter into a detailed account of the history of the investigation of the Sables de Sinceny. It is briefly outlined in Dollfus 1902 (140, where references will be found). M. G. F. Dollfus, after visiting some typical sections of the Blackheath Beds in England, was astounded by their lithological, palæontological, and stratigraphical similarity with a hitherto little-studied bed in France—the "dépôt de Sinceny." In 1878 (133) he published an account of the beds, which he renamed the "Sables de Sinceny," and included a critical list of fossils, using the results of previous workers (particularly Hébert and Lambert). At the same time N. de Mercey had been studying the beds, and his conclusions agreed with those of Dollfus (157–9). Just as with the Blackheath Beds in England, there were many geologists who wished to consider the Sables

* In England the Bottom Bed of the Woolwich Series represents the zone of *Cyprina scutellaria* (Stamp and Priest 55), and hence is of the same age as the Sables de Bracheux. The name "Thanetian," having as type our Thanet Sands, should not therefore be applied to the French "Sables de Bracheux," and should be dropped. The "Sparnacian" of the French cannot be used to include the whole of our Woolwich and Reading Beds. Dumont's term Landenian is especially useful as it includes the deposits of a natural cycle (Stamp 54, see also Leriche 151).

†Spelt "Sainceny" in older writings.

‡On the merits of the term "Ypresian" (Dumont 1849) in preference to "Cuisian" (Dollfus 1880) see Lemoine (149).

PROPOSED CORRELATION OF THE LANDENIAN AND YPRESIAN OF THE ANGLO-FRANCO-BELGIAN BASIN.

	LANDENIAN.			YPRESIAN.		
LONDON BASIN—WEST	—	Woolwich Bottom Bed (Zone of *Cyprina scutellaria*) (marine)	Woolwich & Reading Beds—Reading type (fluviatile)	—	Basement Bed of the London Clay	London Clay
CENTRE	Thanet Sand (marine) (? = Zones of *Cyprina Morrisi* and *Pholadomya Koninckı*)		Woolwich type (estuarine)	Blackheath Beds (pebbly type)		
EAST			Marine type.	Oldhaven Beds (sandy type)	[Basement Bed]	
NORTHERN FRANCE	Lower Landenian, (marine). Zones of *Cyprina Morrisi*, *Pholadomya Koninckı*, and *Cyprina scutellaria*.		Upper Landenian, fluviatile passing to estuarine near Ostend in the N.W.	Pebble bed and sand	—	Argile d'Ypres
BELGIUM				Pebble bed Ya and sand Yb	—	Argile yprésienne Yc and sable yprésien Yd
FRANCE—COAST OF ENGLISH CHANNEL	—	Zone of *Cyprina scutellaria*	Estuarine beds of Woolwich type.	Pebbles (Galets de Oldhaven) & sand	—	Clay
HAMPSHIRE BASIN. WEST	—	Marine Bottom Bed (Zone of *Cyprina scutellaria*)	Reading type (fluviatile)	—	Basement Bed of the London Clay	London Clay
EAST	—		Woolwich type (estuarine)			
PARIS BASIN—CENTRE	Lower Landenian (marine) Zones of *Pholadomya Koninckı* (tuffeau of La Fère) and *Cyprina scutellaria* (sands of Bracheux)		Upper Landenian Woolwich type (estuarine)	Sables de Sinceny	Basement Bed of the Cuise Sands	Cuise sands (marine)
PERIPHERY	—	—	Reading type (fluviatile)	—		

de Sinceny as part of the Sparnacian, and this view is still retained by a few. However, the original opinion of Dollfus and de Mercey, demanding the separation of the beds, has come to be generally accepted. In 1902 Dollfus (140) published a partial revision of the fossil-lists and Leriche (111) in 1912 pointed out very clearly the stratigraphical relations of the beds. I cannot do better than to quote his words :—

" Among the fossils of the Sables de Sinceny, some (autochthonous) were living in the Landenian lagoons at the time of their invasion by the Ypresian sea ; others (allochthonous) form part of the fauna proper to that sea and determine the age of the deposit, these are the species of the Sables de Cuise. To these may be added certain forms special to the horizon of the Sables de Sinceny " (pages 730–1). The Sables de Sinceny are surmounted at Sinceny itself by a thin argillaceous band with *Ostrea bellovacensis*. This fact has been used by some as an argument for grouping the Sables de Sinceny with the " lignites du Soissonais " (i.e., the Upper Landenian). It has also been argued that the distribution of the black flint pebbles agrees with that of the lignites rather than with that of the Sables de Cuise. This, however, is only to be expected. The fine Sables de Cuise would be completely removed by denudation, but the larger pebbles of the underlying Sables de Sinceny would still be left scattered over the surface. The same is true of the Blackheath Beds in England.

In the early part of the present century an interesting deposit was discovered near Pourcy to the south-west of Reims (148, 162). This locality is almost on the southern limit of the Ypresian sea and the marine Sables de Cuise are very thin. The Pourcy deposits consist of pebbly sands with pockets of shells, and probably occupy an old channel. The fauna is similar to that of the Sables de Sinceny, and there can be little doubt that the " Faluns de Pourcy " were deposited near the mouth of a river which emptied into the Ypresian sea. Whilst the deposit may be slightly younger than the Sables de Sinceny, it has a very similar mixed fauna.

To avoid a long list of localities in which the Sinceny Beds have been found, they have been indicated on the map (Plate 3), which also shows the close connection, in horizontal distribution, of the Sinceny Beds and the estuarine clays of the Upper Landenian. This is exactly as we have seen in the London Basin.

With regard to the Cretaceous areas separating the Paris and Belgian " Basins " and the main part of the former from the English Channel, not only are there numerous occurrences of the typical well-rounded black flint pebbles from the base of the Ypresian in the Quaternary, but there are also several large

outliers of the Sinceny Beds. Their former continuity is therefore certain. The deposits in some of these outliers, particularly near Lihons (Somme)—(see Leriche 156)—recall very strongly the non-fossiliferous type of Blackheath Pebble Beds. An outlier which may be mentioned because of its northerly situation has been found at Saint Saens, north of Rouen (Dollfus, 136), and has yielded a typical series of fossils.

The close affinities of the faunas of the Sinceny and Blackheath Beds are mentioned below (page 93).

VII. THE PALÆONTOLOGY OF THE BLACKHEATH-SINCENY BEDS.

Despite the obvious close affinities of the Blackheath and Sinceny faunas, a comparison of the existing fossil-lists did not show this. Accordingly, an attempt has been made to revise the faunal list of the Blackheath Beds. Imperfect as the attempt certainly is, it is hoped that it may prove of some service to the field geologist. The difficulty experienced by the amateur in attempting to name correctly his fossils often lies in not knowing where to find a characteristic illustration or a correctly labelled specimen. Limitation of space has made it impossible to give a bibliography of each species, but where possible a reference has been given to a characteristic published figure, and, in the case of some rarer species, to an exhibited specimen in one of the London Museums.

Apart from the original descriptions of some species scattered through various publications, the following are the more important compilations :—

J. Sowerby *Mineral Conchology of Great Britain* (M.C.) 1812-46, 7 vols. Index in vol. vii. The type specimens are exhibited in the British Museum (Natural History).

G. P. Deshayes *Description des Coquilles Fossiles des Environs de Paris* (C.F.) 1824-37. Vol. 1 Pelecypoda, vol. 2 Gasteropoda.

G. P. Deshayes *Description des Animaux sans Vertèbres découverts dans le Bassin de Paris* (A.V.) 1856-66 vol. 1 text and vol. 1 atlas, Pelecypoda, Vol. 2 and 3 text vol. 2 atlas Gasteropoda.

S. V. Wood *Eocene Bivalves* vol. 1 (*E.B.*) 1861-77
and F. E. Edwards *Eocene Univalves* vol. 1 (E.U.) 1849-77 { Mon. Pal. Soc.
Unfinished owing to death of authors.

M. Cossmann *Catalogue illustré des Coquilles Fossiles de l'Eocène des environs de Paris* (C.I.). A critical review of Deshayes' work with illustrations of a few species only. Published in Ann. Soc. roy. Malacologique de Belgique Vols. 22 (1887), 23 (1888), 24 (1889), 26 1891), 28 (1893), 31 (1896), 36 (1902), 41 (1907).

R. B. Newton *Systematic List of the F. E. Edwards' Collection of British Oligocene and Eocene Mollusca in the British Museum (Natural History)*

1891. The collection is exhibited. A valuable summary but not illustrated.

M. Cossmann and G. Pissarro *Iconographie Complète des Coquilles fossiles des Environs de Paris* (I.C.) Vol. 1 (1904–6) Pelecypoda, Vol. 2 (1910–13) Gasteropoda. A magnificent photographic atlas of all the Eocene mollusca of the Paris Basin, arranged in same order as the "Catalogue illustré."

For the sake of uniformity the nomenclature adopted in this paper is that of the last mentioned work ; it is a publication that should be available for reference in all libraries, and where possible the references given below to characteristic illustrations are to this work. A note is appended in the few cases where Cossmann's nomenclature differs from the usual English one. Sub-generic names are indicated by round brackets ; well-known generic names formerly in use by square brackets. In the references the two letters indicating the work are followed by the number of the volume (Arabic numerals), page (where quoted Arabic numerals), no. of plate (Roman numerals), no. of figure (Arabic numerals).

Other abbreviations : G.S. = Geological Survey Museum, Jermyn Street, followed by number of case and specimen. B.M. = British Museum (Natural History) ; Ed. = Edwards' Collection ; Sow. = Sowerby Collection, followed by number of case and specimen.

Degree of rarity : C = very common ; c = common ; r = uncommon ; R = rare.

S = occurs in the Sinceny Beds ; B = occurs in the Blackheath Beds. An asterisk indicates that the species has not been personally examined by the author ; these species are only included when there seems no reason to doubt the record.

The following list of fossils from the Blackheath Beds has been based on a study of specimens collected personally, and of specimens (the locality of which is accurately known) from several private collections. Additions have been made from a re-examination of the exhibited series in the Geological Survey Museum. The knowledge concerning matrix and conditions of preservation so gained has been utilized in studying the British Museum collections—especially the Edwards' Collection—where one is faced with the necessity of separating the specimens coming from the Blackheath Beds from those collected from the Woolwich Beds. One or two additions have been made from the study of the Parsons' Collection in the Grange Wood Museum, and a few species are included which I have not personally examined, but which seem to have been recorded on very good grounds.

Fauna of the Blackheath Beds.

Column 1.—Degree of Rarity.
Column 2.—Occurrence of rare forms: B = Bickley; Br = Bromley; C = Charlton; E = Elmstead (Sundridge); U = Upnor; Sw = Swanscombe.

	Species.	1	2	References and Remarks.
	PELECYPODA.			
*	*Teredina personata* Lamk.	R	C	IC1, i, 6–1. Geol. Lon. i, 237.
*	*Teredo antenautæ* Sow.	R	C	Geol. Lon. i, 237.
S	*Barnea* [*Pholas*] *Levesquei* Wat.	R	E	B.M. Ed. vi, 73123; G.S. 55/58 (Recorded in Geol. Lon. i, 237 as *Pholas* from Westminster) IC1, i, 7–1.
*	*Glycimeris* [*Panopæa*] *intermedia* Sow.	R		Geol. Lon. i, 237. Croydon and Higham.
S	*Corbula regulbiensis* Mor.	C		=*C. spectabilis* Desh. Q.J.G.S. x ii, 3a–b; IC1, iii, 20–19. , Plate 2, fig. 7.
	inc. var *b* Mor (= *C. Morrisi* Edw. MSS.)			
S	*Corbula* (*Agina*) *Arnouldi* Nyst	r	B	B.M. Ed. v, ; Q.J.G.S. x, ii, 4–6; IC1, iii, 20–8.
S	*Tellina* (*Mœrella*) *Beyrichi* ? Desh.	R	E	G.S. 55/57; IC1, vi, 35–16.
	Tellina spp.		B, Br, U	B.M. Ed. three or four MSS. species.
	Meretrix (*Pitaria*) *obliqua* (Desh.)	r	U, Sw.	B.M.Ed. v, 72883; IC1, x, 50–9.
*	*Dosiniopsis bellovacensis* ? (Desh. *em.*)	r	U	B.M. Ed.; IC1, xii, 52–2.
	D. orbicularis (Ed. MSS.) (Mor.)	r	U, Sw.	B.M. Ed. v, 72905; IC1, xii, 52–3.
	Cyrena (*Corbicula*) *cordata* Mor.	c		= *C. veneriformis* Desh.
	mut. *sororcula* Ed. MSS.	c	U	
?S	mut. *britannica* Desh.	r	U	aff. *C. Gravesi* Desh.
S	*C. cuneiformis* Fér.	C		including *C. strigosa* S. Wood.
S	*C. Forbesi* Desh.	r		
	C. angustidens Mell.	C		
S	*C.* (*Tellinocyclas*) *tellinella* Fér.	C		
	Cyprina scutellaria ? Lamk.	r	U	IC1, xvi, 68–1.
	Nemocardium [*Protocardium*] *Laytoni* (Mor.)	c		Q.J.G.S. x, ii, 1–2.
	N. plumstediense (Sow. *em.*)	c		B.M. Sow. (*Cardium plumstedianum* Sow.)
?S	*Phacoides* [*Lucina*] *uncinatus* ? (Defr.)	R	B.	*Lucina primæva* Ed. MSS.; B.M. Ed. iv, 72737; IC1, xxvi, 82–37.
S	*Nucula fragilis* Desh.	r	B, Br	including *N. gracilenta* S. Wood and *N. sextans* Ed. MSS. (S. Wood) E.B. xx, 6, 8a–b; B.M. Ed. iv, 72572, 72580; IC1, xxxiii, 104–9.
	Axinæa [*Pectunculus*] *plumstedensis* (Sow.)	C		= *A. polymorpha* (Desh.)
S	mut. *paucidentata* Desh.	C		
	mut. *brevirostris* Sow.	C		
S	*Arca modioliformis* Desh.	r	E, C	E.B. xiv, 5a–b; IC1, xxxvi, 110–38. Including *A. depressa* Sow ? E.B. xiv, 4a–b; and *A. dulvichiensis* Ed. MSS. (S. Wood) E.B. xv, 6a–b, 15. Including G.S. 55/51 recorded as *A. Laekeniana* ? Le Hon; Geol. Lon. i, 237.
	Modiola dorsata Mor.	r	E	B.M. Ed. iii, 72511; Q.J.G.S. x, ii, 14.
	M. Mitchelli Mor.	c	E, C	B.M. Ed. iii, 72505 Q.J.G.S. x, ii, 12–13.
S	*Ostrea bellovacensis*† Lamk *em.*	C		including *O. edulina* Sow. and *O. pulchra* Sow.
S	*O. tenera* Sow.	C		
S	*O. heteroclita* ? Desh.	C		
	GASTEROPODA.			
S	*Neritina globulus* Fér.	C		= *N. uniplicata* Sow.
	N. subornata ? d'Orb.	?		
	N. vicina ? Mell.	c		

†The specific name *bellovacensis* is adopted in this paper in preference to *bellovacina*. Whilst the latter is more usual in England, the former is almost exclusively used on the Continent. As stated above the nomenclature used throughout this paper is that of Cossmann, and, amongst other reasons, it seems unwise to depart in this one case from a nomenclature that is sound, consistent and widely accepted. The form *bellovacensis* has been used repeatedly in these *Proceedings* (Harris and Burrows 144, Stamp 52, 53), whilst *bellovacina* appears in the fossil lists of my recent paper (Stamp and Priest 54). This was an editorial correction and not in accordance with the wishes of the author.

	Species.	1	2	References and Remarks.
	GASTEROPODA.			
S.	*N. consobrina* Fér.	c		including *N. pisiformis* Fér.
	N. elegans Desh.	r	E B	
	Odontostomia [*Odostomia*] *regularis* Ed. MSS.	r	E	B.M. Ed. vii, 71753; G.S. D54/42 labelled "*Melania* ?" ? = *O. Deshayei* Briart and Cornet, IC2, lxiii, 44–1.
?S	*Odontostomia* sp.	r	E	G.S. D54/53, 44809.
	Scala (*Coniscala*) *Bowerbanki* ? Mor.	R	E	G.S. D54/51, 44771–2; IC2, vii, 52–25.
S	*Natica* (*Sigaretopsis*) *infundibulum* Wat.	c		B.M. Ed. ix, 71634; A.V. 2 lxv, 17–19.
	N. (*Naticina*) *labellata* Lamk.	c		=*N. glaucinoides* Sow.; B.M Ed. ix; IC2, x, 61–31.
*	*Ampullina* [*Natica*] *patula* (Lamk.)	R		Near Higham. Geol. Lon. i, 237; IC2, x, 64–3.
S	*Calyptræa aperta* (Sol.)	c		=*C. trochiformis* (Sol) =*Infundibulum echinalatum* Sow. B.M. Sow.; IC2, xii, 73–1.
S	*Viviparus suessoniensis* (Desh.)	R		= *V. sub-lentus* (d'Orb) = *V. lentus* (Sow.) var. B. Morris, non *V. lentus* (Brand); IC2, xiii, 85–3.
?S*	*Bithinella Websteri* (Mor.)	c		Q.J.G.S. x, ii, 22a–b.
*	*Stenothyra Parkinsoni* (Mor.)	c		Q.J.G.S. x, ii 21a–b.
S	*Melania inquinata* (Defr.)	c		IC2, xviii, 114–1; including *Cerithium gracile* Mor. Q.J.G.S. x, ii, 19.
S	*Melanopsis buccinoidea* Fér.	C		
	M. Laubrierei ? Coss.	c		
S	*M. ancillaroides* Desh.	r		
?S	*M. sodalis* Desh.	r		
*	*Turritella* sp.	r	E	and near Higham. Geol. Lon. i, 236.
S	*Batillaria* [*Lampania*] *turbinoides* (Desh.)	r	C	IC2, xxx, 152–17.
S	*B. turbinoides* var. ?	r	C	=*Cerithium Bowerbanki* Mor. Q.J.G.S. x, ii, 19.
	Batillaria (?) *Lunnii* (Mor.)	r	C	? = *B. Stueri* Cossm. IC2, xxx, 152–22.
S	*Tympanotomus* [*Potamides*] *funatus* (Mant.)	C		with several allied species, including *P. crassus* Ed. MSS., IC2, xxix, 151 bis–7.
*	*Aporrhais Sowerbyi* Mant.	r		Near Higham and Hoo. Geol. Lon. i, 236.
	Pyrula tricostata (Desh.)	R	E	Parsons Coll., Grange Wood Museum, IC2, xxxiii, 164–5.
*	*Murex* sp.	R	C	Geol. Lon. i, 236.
S	*Tritonidea* [*Pisania*] *lata* (Sow.)	C		
	Tritonidea			and allied genera, several species.
	Pseudoliva fissurata Desh.	r	B	B.M. Ed. vii, 71557; IC2, xxxvi-vii, 177–3.
S	*P. laudunensis* (Defr.)	r	E B	=*P. semicostata* Desh., B.M. Ed. vii, 71556; IC2, xxxvi, 177–2. G.S. D54/48, 44795 (a rolled specimen recorded as *Pitharella Rickmani*, Geol. Lon. i, 236).
	Actæon turgidus (Desh.)	r	E B	B.M. Ed. ix, 72357; G.S. D54/52a, 7627, 44808; A.V.2, xxxvii, 14–15. Fig. in IC2 not good.
*	*Ringicula turgida* Charlesworth	R	E	Geol. Lon. i, 236.
S	*Planorbis* (*Anisus*) *hemistoma* Sow.	c		IC2, lvii, 254–18.
?S*	*Auricula pygmæa* Mor.	?		Q.J.G.S. x, ii, 17a–b.

In preparing the above list, no attempt has been made to subdivide certain species-groups. Particularly in the case of *Tympanotomus* [*Potamides*] *funatus* Mantell, there is scope for a detailed evolutionary study along the lines followed by the late Jean Boussac in his work on the Paris Basin *Cerithia*.

Sufficient material for the study of the French species of *Tritonidea* has not come into my hands, and for this reason the English species have not been separated.

In addition to the Mollusca, the fauna of the Blackheath Beds includes the crustacean *Cytheridea Ruperti* Dollfus ; several species of Bryozoa ; the sponge *Cliona erodens* Dollfus, and other invertebrates. So far as I am aware, the vertebrate remains have not been studied in detail, but the fauna—especially of fish teeth—is a rich one. Again the lack of French material has made the study of little immediate value for the present purpose of correlation.

The marine type of Oldhaven Beds (East Kent) has a fauna which includes most of the marine species in the above list, together with a few additions (see Whitaker 62 p. 579).

The following list of fossils from the Sinceny Beds is based on that given by Dollfus (133) in his original paper on these beds. The latter was partly revised by Cooreman and Dollfus in 1902 (131 and 140) but some of the corrections then made are inadmissible. Some alterations have been made as a result of the study of a collection in the Musée Gosselet of the University of Lille and of specimens personally collected at Sinceny. This study has been aided by the use of some MS. notes of Prof. Leriche preserved at the University of Lille. Additions have also been made from Cossmann (C.I. and I.C.), and information contained in the following papers has been incorporated :— Leriche 163, 111 ; Ramond in 131.

Fauna of the Sinceny Beds.

Column 1.—Occurrence in the Upper Landenian.
Column 2.—Degree of rarity in the Sinceny Beds.
Column 3.—Occurrence in the Sables de Cuise (Ypresian).

	Species.	1	2	3	Remarks.
	PELECYPODA.				
B	*Barnea Levesquei* Wat.		r	*	
	* *Martesia* [*Pholas*] *proxima* (Desh.)	*	r	*	
	Sphenia angulata Desh.		r		
	* *Corbulomya seminulum* Desh.		r	*	
B	*Corbula regulbiensis* Mor.		r		=*C. spectabilis* Desh. Also in L.L.+
B	*Corbula* (*Agina*) *Arnouldi* ? Nyst		c		This small species is fairly common, though apparently not recorded.
	Mactra Lamberti Desh.		r	*	
	* *Meretrix* (*Pitaria*) *Lamberti* (Desh.)		r		
	* *M.* (*Callocardia*) *sincenyensis* (Desh.)				
	Cyrena sincenyensis Desh.	—	r	—	
	* *C. Lamberti* Desh.		r		
?B	*C.* (*Corbicula*) *Gravesi* Desh.		r	*	
B	*C.* (*Corbicula*) *cuneiformis* Fér.	*	C		
B	*C.* (*Corbicula*) *Forbesi* Desh.	*	c		
B	*C.* (*Tellinocyclas*) *tellinella* Fér.	*	C		
	C. (*Donacopsis*) *Heberti* Desh.	—	r	—	
	* *Cardium porulosum* Lamk.		R	*	Recorded from near Compiegne (133).
	Diplodonta (*Felaniella*) *sinceny-ensis* Desh.		r	*	
?B	* *Phacoides* (*Lucinoma*) *proxima* (Desh.)		R	*	
	* *Microstagon* [*Pisidium*] *lævigatum* (Desh.)	*	r		
B	* *Nucula fragilis* Desh.		R		

+ L.L. — Lower Landenian.

	Species	1	2	3		Remarks.
	PELECYPODA					
B	*Axinæa* [*Pectunculus*] *paucidentata*			C		Also in L.L. Some specimens identical with *A. plumstediensis* Sow. mut. *paucidentata*
B	*Arca modioliformis* Desh.			c	*	
?B	*A. obliquaria* Desh.			r	*	S. Wood (E.B., 82–3) notes superficial resemblance to some English specimens too poorly preserved for accurate identification.
	* *Modiolaria hastata* Desh.			r		Recorded from Canly (133).
	* *Mytilus lævigatus* Desh.		*	r		
	* *M. Levesquei*			r	*	
B	*Ostrea bellovacensis* Lamk. *em.*		*	C		
B	*O. tenera* Sow.		*	C		= *O. sparnacensis.*
B	*O. heteroclita* Desh.		*	c		
	GASTEROPODA.					
B	*Neritina globulus* Fér.		*	r		
	N. sincenyensis Desh.			C		
	* *N. Dutemplei* Desh.			r		
	* *N. nucleus* Desh.			r	*	
B	*N. consobrina* Fér.		*	r		
?B	*Odontostomia* [*Odostomia*] *lignitarum* Desh.		*	r		
	var. *cuisensis* Coss.			r	*	
B	*Natica* (*Sigaretopsis*) *infundibulum* Wat.			r	*	
	* *N.* (*Naticina*) *consobrina* Desh.			r		
B	*Calyptræa aperta* (Sol.)			r	*	
B	*Viviparus suessoniensis* (Desh.)		*	r		
?B	*Bithinella alta* (Desh.)		*	c		} possibly including the Blackheath
	* *B. intermedia* (Mell.)		*	c		} species, *B. Websteri* (Mor.)
	* *Stenothyra pulvis* (Desh.)			r		Recorded from Canly (133).
B	*Melania inquinata* Defr.		*	c		
	Faunus (*Melanatria*) *ornatus* (Desh.)		*	r		
	* *F.*(*Pirenopsis*) *rissoinæformis* Coss.					
B	*Melanopsis buccinoidea* Fér.		*	c		
B	*M. ancillaroides* Desh.			r		
*	*M. Dutemplei*			r		
?B	*M. ovularis* Desh.			r	*	
	* *Paludomus sincenyensis* Coss.			r		
	* *Bayania tritícea* (Fér.)			C	*	
	* *B. herouvalensis* (Desh.)			r	*	
	Cerithium stephanorum Desh.			r		
B	*Tympanotomus* [*Potamides*] *funatus* (Mant.)		*	C		and allied species, including *T. involutus* and *T. turris* Desh.
B	*Batillaria* [*Lampania*] *turbinoides* Desh.		*	C		
B	var.			c		? = *Cerithium Bowerbanki* Mor.
	* *B. subacuta* d'Orb.			r	*	
?B	* *Murex plicatilis* Lamk.			R	*	
B	*Tritonidea* [*Pisania*] *lata* (Sow.)			C	*	
B	*Pseudoliva laudunensis* (Defr.)			r	*	
	* *Terebra* (*Hastula*) *plicatula* (Lamk.)			R	*	
B	*Planorbis* (*Anisus*) *hemistoma* Sow.			R		
	* *P.* (*Menetus*) *lævigata* Desh.		*	R		
?B	*Auricula* (*Semiauricula*) *Dutemplei*		*	r		
	* *Physa* (*Amplecta*) *Lamberti* Desh.			R		

In addition to the mollusca, the fauna of the Sinceny Beds includes the crustacean *Cytheridea Ruperti* Dollfus ; some species of Bryozoa ; the sponge *Cliona erodens* Dollfus and various vertebrate remains.

As mentioned above, the deposits at Pourcy are probably slightly younger than the Sinceny deposits. The presence of a large number of thick-shelled modifications of Sinceny species gives the assemblage of fossils a distinctive character. The list given by Tuniot (162) is now out of date, as a number of these modifications have received special names, and the Pourcy

fauna includes a large number of species not recorded from elsewhere. For that reason, the Pourcy species have not been included in the list of species of the Sinceny Beds.

Comparison of the Faunas of the Blackheath and Sinceny Beds.

The close affinity of the two faunas is easily seen from the foregoing lists.

Blackheath Beds.

32 Pelecypoda, 13 occur in Sinceny Beds plus two somewhat doubtful.
15 of common occurrence, 7 of which are found in the Sinceny Beds.
36 Gasteropoda, 14 occur in Sinceny Beds plus four somewhat doubtful.
14 of common occurrence, 10 in Sinceny Beds.

Sinceny Beds.

30 Pelecypoda, 12 occur in Blackheath Beds plus three somewhat doubtful.
9 of common occurrence, *all* of which are found in the Blackheath Beds.
36 Gasteropoda, 14 occur in Blackheath Beds plus five somewhat doubtful.
10 of common occurrence, 7 in Blackheath Beds.

Notes on Certain Species.

Cyrena (*Corbicula*) *cuneiformis* Férussac (group) E.B. Supp. 5 pl. A 3a-c ; I.C.1. xiv 57–19.
including *C. strigosa* S. Wood, E.B. Supp. 5 pl. A 4.
C. Deshayesi Hébert, A.V.1. 516, xxxvii 19–21.
C. trigona Desh. *non* Wood, C.F.1. 118, xix 16–17.
Cyrena (*Corbicula*) *Forbesi* Desh. . I.C.1. xiv 57–17.
(Fig. in E.B. Supp. pl. A. is not typical.)
Cyrena (*Corbicula*) *antiqua* Férussac. I.C.1. xiv 57–18.

It has long been recognized that *C. cuneiformis* is a very variable species. There are really two extreme forms ; one is a very inequilateral and elongated form which corresponds closely to the type and for which the name *C. cuneiformis* is appropriately reserved ; the other is much shorter compared with its breadth and consequently less inequilateral, and is the form described by Deshayes as *C. Forbesi* ; *C. antiqua* closely resembles the latter, but differs in having a much thicker shell and a broader hinge line and in being somewhat more inflated and angular. It seems advisable to retain these three species, recognising at the same time that they are connected by an infinite number of varieties. Speaking generally the form characteristic of the Upper Landenian (Woolwich Beds) of England and France is the elongated form of *C. cuneiformis*. This also occurs in the Blackheath Beds (especially at Upnor), but the most characteristic form of this horizon is a somewhat shorter variety of *C. cuneiformis*. At Charlton and Sinceny the specimens are also smaller than in the Woolwich Beds, but at Upnor large specimens are common. Under the name *C. strigosa*, S. Wood separated

off those specimens of *C. cuneiformis* which had more pronounced growth ridges, and he mentions that they are equally common with *C. cuneiformis* at Charlton. A more marked variety of *C. cuneiformis* is the characteristic form at Pourcy. It occurs associated with *C. antiqua*, and differs from the typical form in the same way that the latter differs from *C. Forbesi*, namely, in having a thicker shell, broader hinge line, and more pronounced growth ridges. One cannot help thinking that the differences of many of this and other species from Pourcy are largely due to conditions of temperature, etc. *C. Forbesi* occurs, though not very abundantly, in the Blackheath Beds and more frequently in the Sinceny Beds. I have not seen *C. antiqua* from England ; it is abundant at Pourcy and is also said to be very common locally in the Upper Landenian of France. The young of *Cyrena cuneiformis* are also very variable and, as Cossmann has pointed out, the forms named *C. trigona* by Deshayes must be considered as immature forms of this species. Some of the smaller forms intermediate between *C. cuneiformis* and *C. Forbesi* seem to agree with the description of *C. Deshayesi* Hébert, which Cossmann considers indistinguishable from *C. cuneiformis*.

Cyrena (*Corbicula*) *cordata* Morris 1854, Q.J.G.S. x 158, ii 7-9 ; E.B. Supp. 4, pl. A 2a-c.
= *C. veneriformis* Desh. 1857, A.V.I. xxxviii 1-2 ; I C.I. xiii 57-14.

Many years ago Dollfus suggested the identity of the two species. Cossmann regards them as distinct but I am unable to find any difference between the more rounded forms of *C. cordata* and the type figure of *C. veneriformis*, whilst specimens indistinguishable from the typical English *C. cordata* are very common in France. *C. cordata* is abundant and of large size in the Woolwich Beds ; the typical form occurs but rarely in the Blackheath Beds and is then smaller (Upnor, Sundridge).

Mut. *sororcula* Edw. MSS., a smaller and more delicate variety with evenly spaced concentric ridges on the anterior portion. Common at Upnor. B.M. Edw. v. (Plate 2, fig. 6).

Mut. *britannica* Desh. E.B.Supp. pl. B. 2a-b. A shortened form, approaching *C. Gravesi* Desh. B.M. Edw. v.

Cyrena (*Corbicula*) *angustidens* Melleville
= *C. intermedia* Melleville in Desh. Q.J.G.S. x 155, ii 10-11 ; E.B. Supp. 7 pl.A 8a-b ; I.C.I. xiv 57-31.

This little species is very common in the Blackheath Beds at Charlton. Variable, but agrees fairly closely with figures given by Morris and by Wood.

Cyrena (*Tellinocyclas*) *tellinella* Férussac E.B. Supp. 10 pl.A 13a-c ; I.C.1. xiv 57-27.
including *C. singularis* Desh. A.V.1. 508, xxxv 13-15.

In France and England this species is rare and of small size in the Upper Landenian (Woolwich Beds). It is a very common and characteristic species in the Blackheath and Sinceny Beds, where it attains a considerable size. It does not appear to occur above this horizon. Small specimens occur somewhat rarely at Pourcy.

Ostrea bellovacensis Lamk. (*emend.*) E.B. 17, 30, i, iii 1a-b, vii 3a-c.
O. pulchra J. Sow.
O. edulina J. Sow.
O. tenera J. Sow. E.B. 31, vi 1a-b.
= *O. sparnacensis* Defr. I.C.1. xliii 135-17.
O. heteroclita ? Defr. I.C.1. xlii 135-7.

The oysters of the Blackheath Beds are, as usual, very variable. One can distinguish roughly two common groups, that of *O. bellovacensis* and that of *O. tenera*. I do not think it possible to separate *O. pulchra* or *O. edulina* from the first group ; whilst *O. sparnacensis*, a very characteristic fossil of the Sinceny Beds, is inseparable from the elongated form known as *O. tenera* in this country. Both these groups occur in colonies, very abundantly in the Blackheath and Sinceny Beds. There are also other forms—especially smooth, inflated and broad types—which would probably be found to belong to several groups. The French specimens have been grouped under the species *O. inaspecta* Desh. ; *O. profunda* Desh. ; *O. resupinata* Desh. ; *O. heteroclita* Defr. etc. (see I.C.1. xlii, etc.). Specimens in my possession from Upnor seem to agree most closely with the last-named species.

Axinæa [*Pectunculus*] *plumstediensis* (Sow.) 1813 (= *A. polymorpha* (Desh.)) Fig. in E.B. is not good. (Pl. 2, fig. 4).
A. plumstediensis (Sow.) variety near *A. paucidentata* (Desh.) (Pl. 2. fig. 3).
A. plumstediensis (Sow.) variety near *A. brevirostris* (Sow.) I.C.1. xxxiv 109-5. (Pl. 2, fig. 5).
A. paucidentata (Desh.) and *A. terebratularis* (Lamk) I.C.1. xxxiv 109-1 and 109-2. (Pl. 2, figs. 1–2).

The species of *Axinæa* from the Lower Eocene are of very great interest. Dollfus and Leriche have made *A. terebratularis* (Lamk) and *A. paucidentata* (Desh.) synonymous, stating that the latter has a variable number of teeth and often as many as the former. That is true, and the two forms grade into one another, but it is possible to pick out specimens which correspond with Lamarck's type and others which correspond with Deshayes'. As Cossmann points out, *A. terebratularis* has a straighter hinge-

line and more angular shell than *A. paucidentata*. In France *A. terebratularis* is extremely characteristic of the Sables de Bracheux and the Sables de Châlons-sur-Vesle ; that is, of the highest zone of the Lower Landenian. The typical form of *A. paucidentata* is very abundant in the Sables de Sinceny, and seems to be an evolutionary modification of *A. terebratularis*. Both species occur in the marine Woolwich Sands of East Kent, and in the Woolwich Bottom Bed nearer London. In the lower part of the Sables de Cuise in France, the place of *A. paucidentata* is taken by *A. polymorpha* Desh. (= *A. plumstediensis* (Sow.)) with its numerous varieties. In England the evolution took place earlier and it is in the Blackheath Beds that one finds the variable *A. plumstediensis* (Sow.). Sowerby described his species as being " slightly oblique " but this feature is scarcely visible in the type specimens. On the one hand one may find specimens of *A. plumstediensis* quite symmetrical and so inflated as to almost merit the designation *A. paucidentata* ; on the other hand some specimens are larger and so markedly oblique that they are scarcely to be distinguished from *A. brevirostris* (Sow.)—a species very characteristic of the London Clay. These varieties may be matched in the French specimens of *A. polymorpha* and have been named by Deshayes (A.V.1. 855-8).

The influence of unfavourable conditions on the modification of species and multiplication of varieties is very well seen in *A. plumstediensis*. The group is limited in vertical range to the Blackheath Beds and the Basement Bed of the London Clay. It is interesting to note that *A. paucidentata* persisted as the dominant form to a later date in France.

Cossmann in his C.I. 188 entirely misinterpreted Sowerby's *A. plumstediensis*, but the error is corrected in his later work.

Neritina globulus Férussac (=*N. uniplicata* J. de C. Sow.) I.C.2. v 39-6 ; E.U., xxxiv 13a-c. and 18a-b ; C.F. 2, xvii 19, 20.

N. subornata d'Orb. (= *N. ornata* Mellev. ; = *N. gratiosa* Desh.) I.C.2. v 39-1 ; A.V.2. lxvi 27-9.

N. vicina Melleville (= *N. jaspidea* Desh). I.C.2. v 39-2 ; A.V.2. lxv 14-16.

Each of these three species has one prominent tooth in the upper part of the columella. The last two differ from the first mentioned principally in ornamentation. The English specimens are generally named *N. globulus*, but, if the ornamentation were preserved, many would probably be referable to the other two species.

N. consobrina Férussac. Including *N. pisiformis* Férussac I.C.2. v 39–7 ; C.I. 1888 86.

This species has several small teeth on the columella and not one as stated by Wood in E.U. The description and figures

given by the latter are therefore quite incorrect. Many of the English specimens in which the colour-marking is preserved—a variable ornamentation of zig-zag lines roughly coincident with the lines of growth—seem to belong to this species.

N. elegans Desh. C.F.2. xix 3-4. (Plate 2, fig. 9.)

This is a distinctive little species, beautifully marked by bands of dark brown or black, alternating with white. The bands are practically coincident with the lines of growth until they approach the suture, when they are reflected backwards at an angle of only slightly over 90°. The absence of a prominent tooth makes it impossible to refer this species to one of the varieties of *N. vicina*. G.S. D54/34, 44753-4; B.M. Edw. ix. ("*N. vicina.*")

Melanopsis buccinoidea Fér. I.C.2. xix 118–1. G.S. D 54/44 44783-6.

M. Laubrierei? Cossm. I.C.2. xix 118–3; C.I. 1888 p. 282. G.S. D54/43 44781–2, /44 44787, 44789.

M. ancillaroides Desh. I.C.2. xix 118–2. (Plate 2, fig. 8).

M. sodalis Desh. I.C.2. xix 118–5; A.V.2. xxxi 14–15.

The genus *Melanopsis* has been rendered specially difficult by the fact that both *M. buccinoidea* and *M. fusiformis* Morris included several distinct species. The interpretation followed here is that of Cossmann and agrees closely with R. B. Newton p 202. The English specimens from Charlton which have been identified as *M. sodalis* are difficult to distinguish from small *M. ancillaroides*.

Analysis of the Blackheath Fauna.

The typical Blackheath Fauna really comprises four groups.

(1.) Freshwater and estuarine molluscs living in the Landenian lagoon at the time of its invasion by the Blackheath Sea. Most of those that persisted were greatly modified—especially by reduction in size—by the salt-water conditions.

Melanopsis buccinoidea Fér.
Melania inquinata (Defr.)
Tympanotomus funatus (Mant.)
Viviparus suessoniensis (Desh.)
Cyrena cuneiformis Fér.
Ostrea bellovacensis Lamk. *em.*
Ostrea tenera Sow.

(2.) Marine species which had existed in Lower Landenian time, but which migrated away with the oncoming of brackish and freshwater conditions in the Upper Landenian. Those that returned with the Blackheath Sea are generally modified.

Axinæa plumstediensis (Sow.) variety near *A. terebratularis* (Lamk.)
Corbula regulbiensis Mor.
Nemocardium plumstediense (Sow. *em.*)
Cyprina scutellaria Lamk.
Dosiniopsis orbicularis (Edw.)

(3.) Marine species which appear for the first time, but which afterwards become dominant in the London Clay. It is the presence of these new invading forms that determines the age of the deposit. In some localities one may note how they become increasingly abundant towards the higher part of the Blackheath Beds, and link its fauna with that of the Basement Bed of the London Clay.

Actæon turgidus (Desh.)
Calyptræa aperta (Sol.)
Natica labellata Lamk.
Pseudoliva laudunensis (Defr.)
Pseudoliva fissurata (Desh.)
Tritonidea [*Pisania*] spp.
Barnea Levesquei (Wat.)
Axinæa plumstediensis (Sow.) variety near *A. brevirostris* (Sow.)
Arca modioliformis Desh.
Meretrix obliqua (Desh.)
Tellina Beyrichi Desh.
Corbula Arnouldi Nyst.

(4.) A small number of species which seem to have thrived particularly well in the Blackheath conditions and which are almost restricted to these beds.

Neritina globulus Fér.
Natica infundibulum Wat.
Cyrena tellinella Fér.
Axinæa plumstediensis (Sow.)

ANALYSIS OF THE SINCENY FAUNA.

The Sinceny Fauna falls into the same groups as the Blackheath Fauna. Leriche, as quoted above, has shown this, but he has not attempted to distinguish between the returning marine species and the new invaders.

(1.) includes

Melanopsis buccinoidea Fér.
Batillaria turbinoides (Desh.)
Melania inquinata (Defr.)
Tympanotomus funatus (Mant.)
Viviparus suessoniensis (Desh.)
Cyrena cuneiformis Fér.
Ostrea bellovacensis Lamk *em.*
Ostrea tenera Sow.

(2.) and (3.) include

Calyptræa aperta (Sol.)
Pseudoliva laudunensis (Defr.)
Tritonidea [*Pisania*] spp.
Barnea Levesquei (Wat.)
Arca modioliformis Desh.
Corbula regulbiensis Mor.
Corbula Arnouldi Nyst.
Mactra Levesquei d'Orb.

(4.) includes

Neritina sincenyensis Desh.
Diplodonta sincenyensis Desh.
Axinæa paucidentata (Desh.)
Cyrena tellinella Fér.
Cyrena Heberti Desh.
Cyrena sincenyensis Desh.

VIII. SUMMARY OF RESULTS.

The history of the regions under consideration from Upper Landenian to Ypresian times may be summarized as follows.

(1.) In the middle of the Upper Landenian (Woolwich and Reading) Period there existed certain large brackish-water lagoons or estuarine areas. They occupied

(a.) the central part of the London Basin (i.e., the area of the Woolwich shelly clays).

(b.) an area in the North Sea passing into Belgium in the neighbourhood of Ostend.

(c.) the central part of the Paris Basin, stretching northwards to the English Channel from Dieppe nearly to Boulogne and across the Channel to Newhaven and as far westwards as Worthing.

These lagoons or estuarine flats were inhabited by a very characteristic suite of mollusca—especially *Cyrena cordata, C. cuneiformis, Ostrea bellovacensis, Melania inquinata* and *Tympanotomus funatus*—and the deposits laid down in each area consist principally of dark, well-bedded shelly clays. Around these areas is a broad fringe of variable deposits—gravels, current-bedded sands, mottled clays and freshwater limestones—all of fluviatile or lacustrine origin and laid down by waters draining into the estuarine areas. These beds are referred to in England as the Reading type ; in Northern France and Belgium as Upper Landenian (L2) and in the Paris Basin as the deposits of the "Zone périphérique."

(2.) Towards the close of the Upper Landenian period there is evidence of local "silting up" of the estuarine areas and of the encroachment of freshwater conditions over part of them. This is marked in certain localities by the increased abundance of fluviatile mollusca (*Viviparus* [*Paludina*]) and vegetable remains (leaf-beds).

(3.) Then followed an extremely important and wide-spread change. Some earth movements, connected with the uprise of the Weald, caused the estuarine areas of the Upper Landenian to sink.

The sea, coming in England from the east and in France probably from the north-east, flowed very rapidly over these lagoon flats. The change was a large and important one, and naturally physical conditions were considerably disturbed. Varying and powerful currents thus set up cut down into the underlying soft Woolwich strata ; subaqueous shingle banks in continuous agitation were formed. The detrital minerals in the deposits of this sea show that they consist largely of resorted Landenian sediments. Where harder beds existed in the Upper Landenian we find them represented in the pebbles of the succeeding beds, whether in France, Belgium or England ("quartzites"). In some cases even the tenaceous mottled clays are found rolled into clay "pebbles." This invading sea brought with it a characteristic suite of molluscs which, for a time, co-existed with the more adaptable species of the Landenian estuarine areas.

The deposits formed during this marine invasion, which we know under the names Blackheath Beds, Oldhaven Beds and Sables de Sinceny, are thus everywhere characterized by a mixed, but very definite fauna. The estuarine species are essentially

those of the Upper Landenian lagoons, the marine those of the succeeding London Clay. It is the presence of the latter that determines the age of the deposit.

The superposition of the Oldhaven—Blackheath—Sinceny Beds on the Landenian is clear, they always cut down into ("*raviner*") or rest unconformably on them ; there is no evidence of a gradual passage or other indications to support the theory of their contemporaneity with the Upper Landenian or "Sparnacian."

(4.) The disturbed conditions of the first inrush of the sea in Blackheath times settled down into a gentle and continuous submergence and the resumption of the normal sedimentation. That the source of the sediment in the Basement Bed of the London Clay in England and Belgium, was from the west, is shown by the distribution of pebbles. This true Basement Bed of the London Clay is characterized in the English regions by shallow-water marine mollusca (*Cyprinæ*). Occasionally one or two survivals from the Upper Landenian lagoons are found. The Basement Bed passes up generally into the main mass of the London Clay.

From this account it will be seen that the Oldhaven—Blackheath—Sinceny Beds must clearly retain their entirety and independent position, but from a physical and stratigraphical, as well as from a palæontological point of view, they mark the opening phase of the Ypresian (London Clay) and should be grouped with that period.

IX. CONCLUSION.

The completion of even this short paper would have been impossible but for the kind assistance of many friends. In particular I wish to express my indebtedness, in Belgium, to Dr. A. Renier, the Director of the Geological Survey, for permission to use many samples of sand and to study the MS. records of the Survey ; to Prof. F. Halet ; to Prof. M. Leriche of Brussels, not only for personal help, but also for the wonderful lucidity and insight of his published work ; to Prof. J. Cornet and M. J. Heupgen, of Mons. In France my thanks are due to Prof. C. Barrois ; to M. A. Briquet ; to M. E. Leroux of Paris for his able guidance in the Paris Basin ; to M. G. F. Dollfus ; and especially to Dr. P. Pruvost of Lille, who has been my constant host, companion and guide through many months of field work in France, Belgium and Germany. For the loan of specimens I wish to thank Messrs. W. H. Bennett, E. E. S. Brown, A. G. Davis, A. L. Leach, and A. Wrigley. The study of public collections has been assisted by the unfailing courtesy of Mr. J. Allen Howe and Mr.

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X. SELECTED BIBLIOGRAPHY.

References to the original descriptions, etc., are omitted in those cases where the work of previous writers has been summarized in a well-known paper. Such papers are marked "B" (Bibliography).

Papers by two or more authors are inserted under the name of the first mentioned.

The following abbreviations have been used to economise space. The letters denoting the periodical are followed successively by the number of the volume (Roman numerals), the date and the page.

G.M., Geological Magazine.
M.G.S., Memoirs of the Geological Survey; in the case of sheet memoirs only the central town is mentioned in the title.
P.G.A., Proceedings of the Geologists' Association.
Q.J.G.S., Quarterly Journal of the Geological Society.
A.S.G.N., Annales de la Société géologique du Nord.
A.S.G.B., Annales de la Société géologique de Belgique.
A.S.Mal.B., Annales de la Société royale malacologique de Belgique.
B.S.B.G., Bulletin de la Société belge de Géologie.
B.S.G.F., Bulletin de la Société géologique de France.
Ex., Excursion to

A. ENGLAND.

1. Baker, H. A. 'On the Quartzite Pebbles of the Oldhaven (Blackheath) Beds of the Southern Part of the London Basin.' G.M. lvii 1920, 62.
2. ——— and Priest, S. 'Ex. East Wickham and Plumstead.' P.G.A. xxx 1919, 199.
3. Barrow, G. 'Some Future Work for the Geologists' Association.' P.G.A. xxx 1919, 1.
4. ——— and Wills, L. J. 'Records of London Wells.' M.G.S. 1913.

5. Blake, J. H., and Monckton, H. W. ' Reading.' M.G.S. 1903.
6. Blundell, G. E., and Monckton, H. W. ' Ex. Hook, Nately and Basingstoke.' P.G.A. xxii 1911, 240.
7. Boswell, P. G. H. ' The Stratigraphy and Petrology of the Lower Eocene Deposits of the North-Eastern Part of the London Basin.' Q.J.G.S. lxxi 1915, 536. B.
8. Bromehead, C. E. N. in discussion on Mr. W. Whitaker's paper on Worms Heath. Q.J.G.S. lxxv 1919, 30.
——————— see 83.
9. Bristow, H. W. ' Isle of Wight.' 2nd Ed. revised by C. Reid and A. Strahan. M.G.S. 1889, 97.
10. Chandler, R. H. and Leach, A. L. ' Ex. Knockmill (Oaklands) and Cotman's Ash.' P.G.A. xx 1907–8, 532.
11. ——————— ———' Ex. Erith.' P.G.A. xxiii 1912, 183.
12. De la Condamine, H. M. ' On the Tertiary Strata and their dislocations in the neighbourhood of Blackheath.' Q.J.G.S. vi 1850, 440.
13. Davies, G. MacD. ' Ex. Norbury, Mitcham Common and Beddington.' P.G.A. xxx 1919, 75.
14. ——————— ' The Rocks and Minerals of the Croydon Regional Survey Area.' Proc. & Trans. Croydon Nat. Hist. & Sci. Soc. 1915–6, p. 53.
15. ——————— ' Ex. Croham Hurst and the Addington Hills.' P.G.A. xxxii 1921, 27.
16. Dewey, H. and Bromehead, C. E. N. ' Windsor and Chertsey.' M.G.S. 1915.
17. Dibley, G. E. ' A well at Lower Sydenham Gasworks.' P.G.A. xxiii 1912, 198.
18. Evans, C. ' On the Geology of the neighbourhood of Portsmouth and Ryde.' P.G.A. ii 1870–1, 61 and 149.
18a. Fagg, C. C. ' Ex. Caterham and the North Downs.' P.G.A. xxx 1919, 183.
19. Gardner, J. S. ' On the Lower Eocene Section between Reculvers and Herne Bay.' Q.J.G.S. xxxix 1883, 197.
20. ——————— ' On the British Eocenes and their deposition.' P.G.A. vi 1879, 83.
21. Holmes, T. V. ' Ex. . . . Blackheath to Bexleyheath.' P.G.A. xiii 1893-4, 152.
22, 22a. ——————— ' Ex. . . . Grove Park,' etc. P.G.A. xvi 1899-1900, 522; P.G.A. xvii 1901-2, 136.
23, 23a. ——————— and Osman, C. W. ' Ex. . . . Elmstead Cutting. . . .' P.G.A. xvii 1901-2, 368, and 489.
24. ——————— and Sherborn, C.D. ' A Record of Excursions made between 1860 and 1890.' Geol. Assoc. 1891. B.
25. Hopkinson, J. ' Middlesex and Hertfordshire ' in ' Geology in the Field.' Geol. Assoc. 1910, p. 1.
26. Jukes-Browne, A. J. ' Remarks on the Upper Chalk of Surrey.' P.G.A. xix 1905-6, 287.
27. ——————— ' Andover.' M.G.S. 1908.
28. ——————— ' Building of the British Isles.' 3rd Ed. 1911, p. 340.
29. ——————— and White, H. J. O. ' Henley-on-Thames.' M.G.S. 1908.
30. Kidner, H. ' Ex. Bushey and Pinner.' P.G.A. xxii 1911, 152.
31. ——————— ' Ex. Bushey, Oxhey and Watford Heath.' P.G.A. xxii 1911, 278.

32. Klaassen, H. M. 'On a section of the Lower London Tertiaries at Park Hill, Croydon.' P.G.A. viii 1883–4, 226.
33. ——— 'The Pebbly Beds . . . near the Addington Hills, Surrey.' P.G.A. xi 1890, 464.
34. Leach, A. L. 'North Kent and adjoining parts of Surrey.' in 'Geology in the Field.' Geol. Assoc. 1910, p. 236.
35. ——— 'On the Geology of Shooter's Hill, Kent.' P.G.A. xxiii 1912, 112.
36. ——— and Polkinghorne, B. C. 'Ex. East Wickham and Bostal Heath.' P.G.A. xix 1905-6, 341.
37. Meyer, C. J. A. 'On the Lower Tertiary Deposits recently exposed at Portsmouth.' Q.J.G.S. xxvii 1871, 74.
38, 39. Prestwich, J. 'On the Structure of the Strata between the London Clay and the Chalk in the London and Hampshire Tertiary Systems.'
Part I. 'The Basement Bed of the London Clay.' Q.J.G.S. vi 1850, 252. B.
Part II. 'The Woolwich and Reading Series.' Q.J.G.S. x 1854, 75. B.
40. ——— 'On the Correlation of the Eocene Tertiaries of England, France and Belgium.' Q.J.G.S. xi 1855, 206.
41. ——— ditto, Part II. Q.J.G.S. xiii 1857, 89.
42. ——— 'Further observations on the Correlation of the Eocene Strata in England, Belgium and the North of France.' Q.J.G.S. xliv 1888, 88.
43. Priest, S. 'Ex. Plumstead and Bostall Heath.' P.G.A. xxx 1919, 82.
44. Reid, C. 'The Eocene Deposits of Dorset.' Q.J.G.S. lii 1896, 490.
45. ——— 'The Eocene Deposits of Devon.' Q.J.G.S. liv 1898, 234.
46. ——— 'Dorchester.' M.G.S. 1899.
47. ——— 'Southampton.' M.G.S. 1902.
48. ——— 'Ringwood.' M.G.S. 1902.
49. ——— 'Salisbury.' M.G.S. 1903.
50. Sherborn, C. D. 'Note . . . on the Physiography of the Tertiary Sea-Bottom.' P.G.A. xx 1907-8, 330.
51. Sherlock, R. L. 'Ex. Ayot and Wheathampstead.' P.G.A. xxvi 1915, 86.
52. Stamp, L. D. 'Note on the Section exposed in the Railway Cutting between Bexleyheath and Barnehurst Stations.' P.G.A. xxxi 1920, 146.
53. ——— 'Ex. Grove Park and Chislehurst.' P.G.A. xxxi 1920, 150.
54. ——— 'On Cycles of Sedimentation in the Eocene Strata of the Anglo-Franco-Belgian Basin.' G.M. lviii 1921.
55. ——— and Priest, S. 'Geology of the Swanscombe Eocene Outlier, Kent,' P.G.A. xxxi 1920, 187.
56. Treacher, Ll. and White, H. J. O. 'The Higher Zones of the Upper Chalk in the Western Part of the London Basin.' P.G.A. xix 1905-6, 395.
57. Warburton, H. 'On the Occurrence of a Bed of Septaria containing Freshwater Shells, in the Series of Plastic Clay, at New Cross, Kent.' Q.J.G.S. i 1845, 172.
58. Watts, W. W. Presidential Address. 'Geology as Geographical Evolution.' Q.J.G.S. lxvii 1911, lxxi.

59. Whitaker, W. 'The Western End of the London Basin,' etc. Q.J.G.S. xviii 1862, 258.
60. ——— 'On the "Lower London Tertiaries" of Kent.' Q.J.G.S. xxii 1866, 404.
61. ——— 'On the Cliff Sections of the Tertiary Beds west of Dieppe in Normandy and at Newhaven in Sussex.' Q.J.G.S. xxvii 1871, 263.
62. ——— 'The Geology of the London Basin.' M.G.S. iv pt i 1872.
63. ——— (and others) 'N.W. Part of Essex and N.E. Part of Herts.' M.G.S. 1878.
64. ——— 'Ipswich, Hadleigh and Felixstowe.' M.G.S. 1885.
65. ——— 'The Geology of London.' 2 vols. M.G.S. 1889.
66. ——— 'A Dozen Years of London Geology.' P.G.A. xvii 1901-2, 342. B.
67. ——— 'The Water Supply of Kent.' M.G.S. 1908.
68. ——— 'The Water Supply of Hampshire.' M.G.S. 1910.
69. ——— 'The Water Supply of Surrey.' M.G.S. 1912.
70. ——— 'Ex. Ewell and Cheam.' P.G.A. xxiii 1912, 245.
71. ——— 'Ex. North Downs, Marden Park.' P.G.A. xxvi 1915, 138.
72. ——— and Davies, G. MacD. 'The Section at Worms Heath, Surrey.' Q.J.G.S. lxxv 1919, 7.
73. ——— and Thresh, J. C. 'The Water Supply of Essex.' M.G.S. 1916.
74. White, H. J. O. 'Ex. Kintbury, Inkpen and Woodhay.' P.G.A. xvii 1901-2, 388.
75. ——— 'Hungerford and Newbury.' M.G.S. 1907.
76. ——— 'Basingstoke.' M.G.S. 1909.
77. ——— 'Berkshire and Part of the Thames Valley' in 'Geology in the Field.' Geol. Assoc. 1910, 210.
78. ——— 'Winchester.' M.G.S. 1912.
79. ——— 'Fareham and Havant.' M.G.S. 1913.
80. ——— 'Lymington and Portsmouth.' M.G.S. 1915.
81. ——— 'Bournemouth.' 2nd Ed. M.G.S. 1917.
82. Young, G. W. '. . . The Tertiary Beds of Herne Bay' in 'Geology in the Field.' Geol. Assoc. 1910, 257.
82a. ——— 'The Chalk Area of North-East Surrey.' P.G.A. xix 1905-6, 190.
83. Geological Survey, Summary of Progress for 1913, p. 29. (C. E. N. Bromehead.)
84. Geological Survey, Summary of Progress for 1914, p. 28.
85. Foucar, J. L. 'The Recent Exposures of Fossiliferous Blackheath Beds at Well Hall, Eltham.' Trans. West Kent Nat. Hist. Micro. and Phot. Soc. 1905-6, p. 17.

B. BELGIUM AND NORTH FRANCE.

86. Briquet, A. 'Observations sur la composition des terrains eocènes inférieurs du Nord de la France.' A.S.G.N. xxxv 1906, 132.
87. ——— 'Galets de Oldhaven sur le Blanc Nez.' A.S.G.N. xxxviii 1909, 160.
88. ——— 'Vestiges de l'étage yprésien à Bourlon et sur le Blanc Nez.' A.S.G.N. xliv 1919, 106.

89. Cornet, F. L. and Briart, A. 'Quelques fossiles des argilites de Morlanwelz.' A.S.Mal.B. xiii 1878, quoted in Mourlon (112) p. 212.
90. Cornet, J. 'Sur quelques affleurements de l'Yprésien à Mons et aux environs.' A.S.G.B. xl 1913, B258.
91. ——————— 'Les terrains tertiaires et crétaciques traversés par les puits du siège de Baudour.' A.S.G.B. xli 1914, B97.
92. ——————— 'Le puits artésien de la Chaussée de Binche à Mons.' A.S.G.B. xlii 1919, B70.
93. Delhaye, F. 'Le puits artésien de Moen.' A.S.G.B. xxxvii 1909, B60.
94. Delvaux, E. 'Documents stratigraphiques et paléontologiques pour l'étude monographique de l'étage yprésien.' A.S.G.B. xiv 1886-7, M 57.
95. ——————— 'Description stratigraphique et paléontologique d'une assise de sables inférieurs à l'argile yprésienne, représentant en Belgique les Oldhaven Beds du bassin de Londres.' A.S.G.B. xix 1891, M83. B.
96. van Ertborn, O. 'Le puits artésien du Royal Palace Hotel à Ostende.' B.S.B.G. xv 1901, P.V. 178.
97. ——————— 'Rectifications à l'échelle stratigraphique de l'Eocene belge.' B.S.B.G. xvii 1903, Mém. 103.
98. ——————— 'Le puits artésien de la teinturerie de M.M. Moens frères . . . à Alost.' B.S.B.G. xvii 1903, Mém 145.
99. Forir, H. 'Sur un puits artésien creusé en 1846 à la station du Nord, place des Nations, à Bruxelles.' A.S.G.B. xxxiii 1905–6, B103.
100. Gosselet, J. 'Légende de la Feuille de Montreuil, suivie des notes d'excursions.' A.S.G.N. xxxv 1906, 7.
101. ——————— 'Légende de la Feuille d'Arras.' A.S.G.N. ixl 1910, 84.
102. ——————— and Dollé, L. 'L'enveloppe crétacique du Bas-Boulonnais.' A.S.G.N. xxxvi 1907, 169.
103. Halet, F. 'Coupes géologiques de quelques sondages profonds trouvés dans les collections de feu le capitaine E. Delvaux.' B.S.B.G. xxii 1908, Mém. 3.
104. ——————— and Malaise, C. 'Le puits artésien de l'usine Thomaes à Renaix.' B.S.B.G. xxiv 1910, P.V. 124.
105. Hankar, A. 'Compte-rendu de la session annuelle extraordinaire de 1895, tenue dans le Nord de la France. B.S.B.G. ix 1895, Mém. 427.
106. Ledoux, A. 'Sur une fôret fossile du Landenien supérieur à Overlaer-lez-Tirlemont.' A.S.G.B. xxxvii 1909–10, M 39.
107. Leriche, M. 'Notice sur les fossiles sparnaciens de la Belgique.' A.S.G.N. xxviii 1899, 280.
108. ——————— 'Observations sur la Géologie de l'Ile de Wight.' A.S.G.N. xxxiv 1905, 32.
109. ——————— 'Les Terrains tertiaries dans le département du Nord' in 'Lille et la région du Nord en 1909.' vol. ii p. 23.
110. ——————— 'Sur l'age des formations sporadiques comprises entre la porphyrite dioritique et l'Argile yprésienne à Quenast.' B.S.B.G. xxvi 1912 P.V. 194.
111. ——————— 'Réunion extraordinaire de la Société géologique de France à Laon, Reims, Mons, Bruxelles, Anvers 1912.' B.S.G.F. 4th Ser. xii 1912, 675.

112. Mourlon, M. 'Géologie de Belgique.' 2 vols, Bruxelles 1880.
113. ——— 'Texte explicatif du levé géologique de la planchette d'Uccle.' Serv. géol. Belg. 1910, 101.
114. Passau, G. 'Note sur les sablières du Bois du Rapois à Havré.' A.S.G.B. xxxvi 1908, M 239.
115. Rutot, A. 'Sur la position stratigraphique des restes de mammifères receuillis dans les couches de l'Eocène de Belgique. Bull. Acad. r. Belg. i 1881.
116. ——— 'Note sur l'allure souterraine des couches entre la Lys et la Senne.' B.S.B.G. i 1887, Mém. 21.
117. ——— 'Note sur la limite orientale de l'étage yprésien dans le N-E. de la Belgique.' B.S.B.G. ii 1888, Mém. 204.
118. ——— 'Le puits artésien de Dottignies-St-Léger.' B.S.B.G. iii 1889, P.V. 18.
119. ——— 'Compte rendu de la Session extraordinaire dans le Hainaut et aux environs de Bruxelles.' B.S.B.G. xvii 1903, Mém. 383.
120. ——— 'Le facies sparnacien du Landenien supérieur aux sablières de la Courte à Leval-Trahegnies.' B.S.B.G. xviii 1904, P.V. 236.
121. Stamp, L. D. 'Note sur la Géologie du Mont Aigu et du Mont Kemmel.' A.S.G.N. xliv 1919, 115.
122. Stevens, C. 'Etude du Landenien supérieur dans le Hainaut.' A.S.G.B. xli 1913–4, M.3.
123. Van den Broeck, E. in 'Compte-rendu de la Session annuelle extraordinaire de 1899 tenue dans le bassin de Londres.' B.S.B.G. xiii 1899, Mém. 300.

C. FRANCE.

130. Combes, P. 'Sur l'extension de l'invasion marine du sparnacien supérieur aux environs de Paris.' C.R. Acad. Sci. cxlii 25 juin 1906, 1574.
131. Cooreman, T. and Dollfus, G. F. 'Compte rendu des excursions . . . dans les départements français de la Marne et de l'Aisne.' B.S.B.G. xvi 1902, Mém. 209.
132. Dollfus, G. F. 'Description et classification des depôts tertiaires des environs de Dieppe.' A.S.G.N. iv 1876–7, 19.
133. ——— 'Les Sables de Sinceny.' A.S.G.N. v 1877–8, 5.
134. ——— 'Essai sur l'extension des terrains tertiaires dans le bassin anglo-parisien.' B.S.G. Normandie vi 1880, 478, 584.
135. ——— Sur l'age du soulèvement du pays de Bray.' B.S.G.F. 3rd Ser. ix 1881, 112.
136. ——— 'Feuille de Lille.' C.R. des Collaborateurs. Bull. S. Carte. géol. Fr. x 1898–9.
137. ——— 'Critique de la classification de l'Eocène inférieur. A.S.G.N. xxxiv 1905, 373.
138. ——— 'On the classification of the Beds of the Paris Basin.' P.G.A. xxi 1909, 101.
139. ——— 'Observations sur la classification . . .' B.S.G.F. 4th Ser. x 1910, .
140. ——— 'Les sables de Sinceny' in (131).

141. Gosselet, J. 'Quelques observations géologiques aux environs de Guiscard et de Sinceny.' A.S.G.N. xxii 1894, 134.
142. ——— 'Note sur les couches de galets de la Feuille de Laon.' A.S.G.N. xxviii 1899, 297.
143. ——— 'Notes sur une nouvelle coupe de Sables de Sinceny dans un jardin.' A.S.G.N. xxxi 1902, 61.
144. Harris, G. F. and Burrows, H. W. 'The Eocene and Oligocene Beds of the Paris Basin.' Geol. Assoc. 1891.
145. Hébert, E. 'Sur la position des Sables de Sinceny.' B.S.G.F. 3rd Ser. vii 1879, 408.
146. Haug, E. 'Traité de Géologie.'
147. Laurent, J. 'Etudes scientifiques sur le pays rémois' Reims 1907 p. 54.
148. ——— 'Le gisement de Pourcy.' Bull. Soc. d'Etude des Sci. Nat. de Reims 1909. Extract p. 9.
149. Lemoine, P. 'Géologie du Bassin de Paris.' Paris 1911.
150. Leriche, M. 'Sur l'âge des Sables à Unios et Térédines des environs d'Épernay et sur la signification du terme sparnacien. B.S.G.F. 4th Ser. iv 1904, 815.
151. ——— 'Sur la signification des termes Landenien et Thanetien.' A.S.G.N. xxxiv 1905, 201.
152. ——— 'Observations sur la classification des assises paléocènes et éocènes du bassin de Paris.' A.S.G.N. xxxiv 1905, 383.
153. ——— 'Observations sur les terrains tertiaires des environs de Reims et d'Epernay.' A.S.G.N. xxxvi 1907, 367.
154. ——— 'Sur la faune ichtyologique et sur l'âge des faluns de Pourcy (Marne).' C. R. Acad. Sci. 19 août 1907, cxlv 442.
155. ——— 'Observations sur la géologie du Cambrésis. A.S.G.N xxxvii 1908, 372.
156. ——— 'Les vestiges de la mer yprésienne entre la Flandre et l'Ile de France.' A.S.G.N. xxxviii 1909, 421.
111. ——— 'Réunion extraordinaire de la Société géologique de France à Laon, Reims, Mons, Bruxelles, Anvers 1912.' B.S.G.F. 4th Ser. xii 1912, 675.
157-159. de Mercey, N. 'Couches de Sinceny,' etc. B.S.G.F. 3rd Ser. vi 1877-8, 198, 679 ; vii 1880, 404, 579, 610.
160. Morrelet, L. 'Etude du tertiaire de la carrière des Quatre Vents près Dieppe.' B.S.G.F. 4th Ser. vi 1906, 84.
161. Parent, H. 'Notes sur les terrains tertiaires du pays de Caux.' A.S.G.N. xxii 1894, 1.
162. Tuniot, A. 'Sur un nouveau gisement fossilifère de la Marne.' [Pourcy]. Bull. Soc. d'Etude des Sci. Nat. de Reims, 1902.
61. Whitaker, W. 'On the Cliff sections,' etc. Q.J.G.S. xxvii 1871, 263.
163. Leriche, M. 'C. R. de l'excursion géologique dans le forêt de St. Gobain.' A.S.G.N. xxviii 1899, 105.

EXPLANATION OF PLATE 2. (FOSSILS.)

FIG. 1.—*Axinæa* [*Pectunculus*] *terebratularis* Lamarck. Landenian Sands (Zone of *Cyprina scutellaria*) Châlons-sur-Vesle, Paris Basin. Interior and side views. (Coll. L.D.S.)

FIG. 2.—*Axinæa paucidentata* Desh. Sables de Sinceny, Sinceny, Paris Basin. 2A interior (Coll. L.D.S.), 2B–C exterior and side views (Musée Gosselet, Université de Lille). The illustrations are of young specimens, the shell is less globose than when old, but the conspicuous umbo, which tends to be much worn in older specimens, is well shown.

FIG. 3.—*Axinæa plumstediensis* Sow. (=*A. polymorpha* Desh.) mut. *terebratularis*. Blackheath Beds, Elmstead Tunnel, Kent. Interior, exterior and side views. (Coll. L.D.S. ex Coll. W. Whitaker). Showing the equilateral shell and protuberant umbo.

FIG. 4.—*Axinæa plumstediensis* Sow. Blackheath Beds, Elmstead Tunnel, Kent. 4A interior (Coll. L.D.S. ex-Coll. W. Whitaker), 4B–C exterior and side views (Coll. L.D.S. collected by P. Escott). Showing the equilateral shell and inconspicuous umbo.

FIG. 5.—*Axinæa plumstediensis* Sow. mut. *brevirostris*. Blackheath Beds, Elmstead Tunnel, Kent. Interior, exterior and side views (Coll. L.D.S. collected by P. Escott). Showing the oblique shell.

FIG. 6.—*Cyrena* (*Corbicula*) *cordata* Morris (=*C. sororcula* Edwards MSS.) Blackheath Beds, Upnor, Kent. (Coll. L.D.S.)

FIG. 7.—*Corbula regulbiensis* var. β. Morris, var. (=*C. Morrisi* Edwards MSS.) Blackheath Beds, Charlton, Kent. (Coll. L.D.S.)

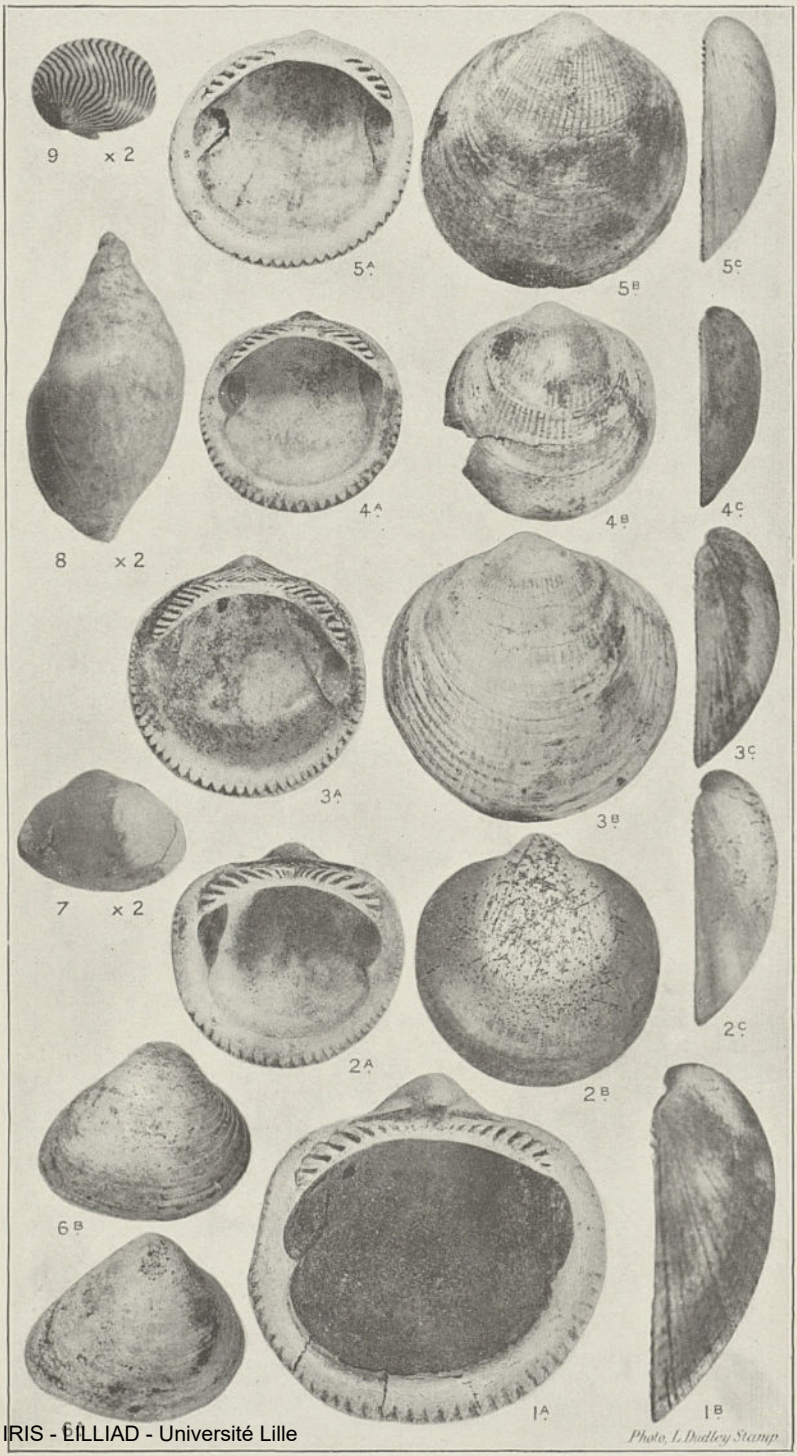
FIG. 8.—*Melanopsis ancillaroides* Fér. Blackheath Beds, Charlton Kent. (Coll. A. G. Davis.)

FIG. 9.—*Neritina elegans* Desh. Blackheath Beds, Elmstead Tunnel, Kent. (Coll. Parsons, Grange Wood Museum.)

FIGS. 1—6 are natural size ; FIGS. 7—9 are magnified 2 diameters.

NOTE.—The choice of young specimens of *A. paucidentata* has accentuated the difference between the hinge line of that species and *A. plumstediensis*. The age of the specimen is, of course, reflected in the size of the area, but it is found that the relative protuberance of the umbo is scarcely affected by age in the species figured.

Since the foregoing paper was put into print, Mr. F. B. Tombleson has kindly given me a pebble of flint-conglomerate (probably Hertfordshire pudding-stone) from the Blackheath Beds of Addington Hills. This specimen considerably strengthens the evidence (IVa) mentioned on pp. 69-70.



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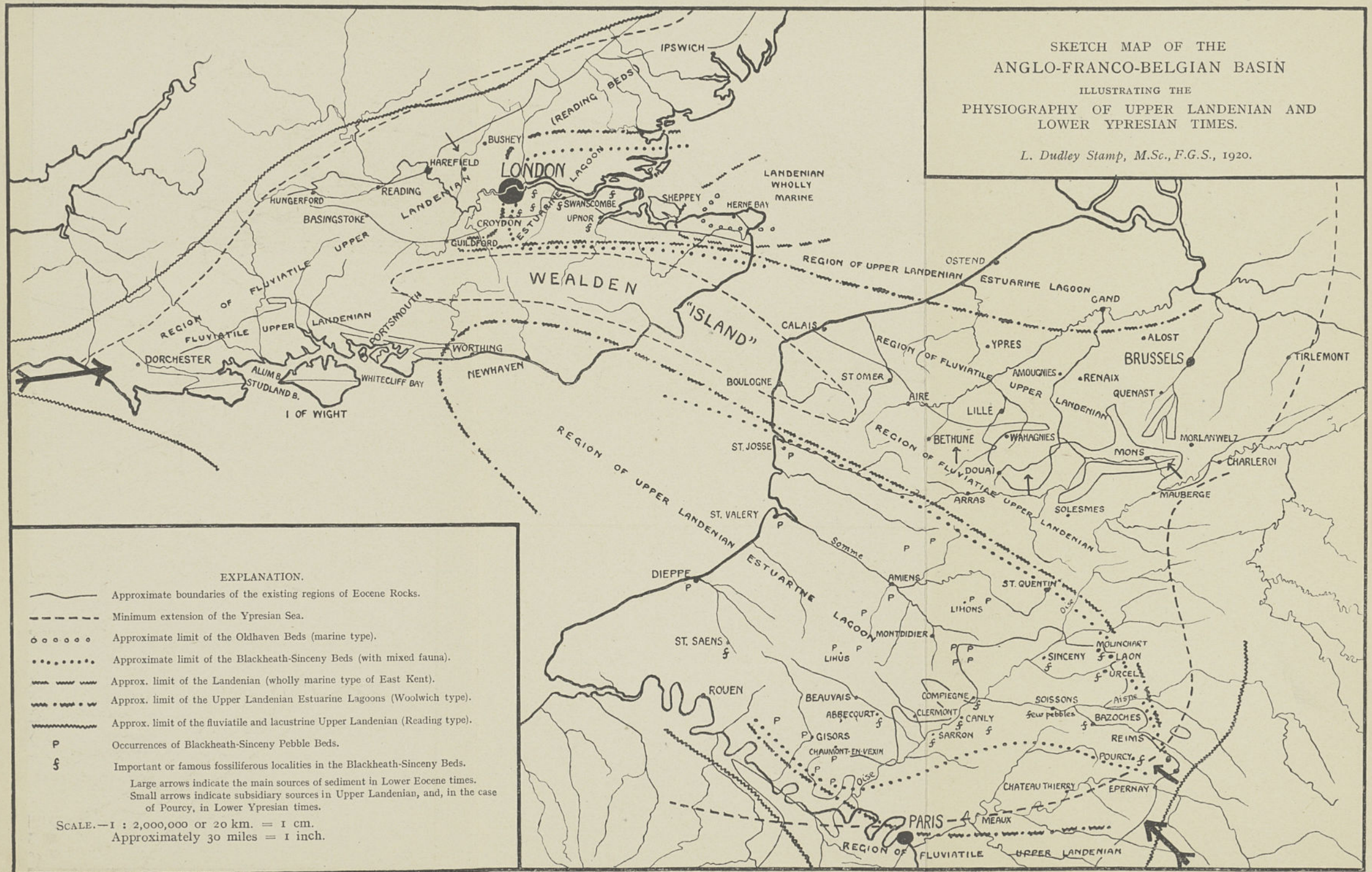

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