NOTICES OF MEMOIRS.

I.—The Conchological Features of the Lenham Sandstones of Kent, and their stratigraphical importance.[1] By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

Part I.

At various points along the summit of the chalk escarpment forming the North Downs of Kent and Surrey and extending from Paddlesworth near Folkestone to Lenham near Maidstone, and thence to Netley Heath between Guildford and Dorking—a distance east and west of about seventy miles—there occur in pockets, cavities, or "pipes" of the Chalk formation, certain scattered masses of a reddish ferruginous sandstone at considerable altitudes above sea-level; at Paddlesworth this sandstone has been observed at 600 feet; at Lenham 680 feet; while at Netley Heath it is found at a height of between 570 and 600 feet. Sandstones of corresponding age are met with in France particularly on the hills between Calais and Boulogne, and on Cassel Hill near Dunkirk at 515 feet; they also occur at Louvain (200 feet) and Diest, both in Belgium, the beds of the latter locality having yielded fossiliferous remains bearing a resemblance to the Lenham fauna, although often differing in specific characters.

The more important of these sandstone deposits, so far as this country is concerned, are those found on the Lenham Downs, as they contain the remains of a marine fauna, chiefly of conchological interest, whereas the beds of other districts are generally unfossiliferous, although it should be mentioned that a few Mollusca of rather uncertain character have been obtained from both Paddlesworth and Netley Heath.

The fossils known in the various museum collections have been mostly obtained from a large disused chalk quarry situated about half a mile to the north of Lenham, of which an excellent sketch may be consulted in Mr. Reid's "Pliocene" memoir of 1890, showing the vertical positions assumed by the fossiliferous sandstone pipes seen in the limestone exposure. It has been generally recognized that such deposits represent the remnants of a marine Tertiary formation belonging to early Pliocene times, although my own investigations have led to somewhat different results, and I am more inclined to refer them to the latest division of the Miocene period.

The organisms occur as casts and cavities in the sandstone, and are frequently in a fragmentary condition, rendering their determination extremely difficult. The walls of the cavities, however, often retain sculpture characters, so that it is possible by the aid of wax impressions to obtain reliable evidence as to external details which

[1] We have just received in a connected form the complete text of Mr. R. B. Newton's valuable memoir "On the Conchological Features of the Lenham Sandstones of Kent, and their stratigraphical importance". This paper formed the subject of his Presidential Address to the Conchological Society of Great Britain and Ireland at Manchester, on October 16, 1915, and was afterwards printed in four parts in the *Journal of Conchology*, vol. xv, 1916–17, making 64 pages, with 4 plates of Mollusca. With the author's kind permission we give an abridged notice.

may be safely used for purposes of identification. To Mr. Clement Reid, F.R.S., we are mainly indebted for most of our later knowledge of the Lenham fauna, his researches forming part of the "Pliocene" memoir before mentioned. At that time Mr. Reid had obtained an important series of fossils from the Lenham Beds for the Museum of Practical Geology, which, after being determined, were systematically referred to in the memoir. In order to facilitate my studies on this subject and to enable me to determine certain collections of similar fossils in the British Museum, especially that formed by Mr. Graham Wallas, I was very kindly allowed to loan this valuable type collection made by Mr. Reid. During my studies in this direction it has been necessary to introduce a certain amount of revision, both among the genera and species as laid down in Mr. Reid's memoir. The larger amount of material available at the present time has also resulted in the determination of additional species, so that the shells are regarded as numbering 77 species, which include 1 Scaphopod, 32 Gastropods, 43 Pelecypods, and 1 Brachiopod, whereas Mr. Reid's conchological list embraced 65 species, consisting of 1 Scaphopod, 27 Gastropods, 36 Pelecypods, and 1 Brachiopod. Among the 32 Gastropods now recognized, a new species has been described under the designation of *Ringiculella lenhamensis*. In view of the fact that no figures have yet been published of Lenham fossils, I have had prepared some photographs of the more important shell-remains, which on account of their reddish-brown colour and their more or less obscure character have not been particularly successful; yet it is hoped they may serve a useful purpose in stimulating the interest of the student who desires to pursue further researches on the conchology of these little-known beds.

To complete the Lenham fauna I have here briefly introduced a list of the other organic remains which are found associated with the shells:—

PISCES.
Selachian vertebræ and a palatal plate as determined by Dr. A. S. Woodward. Coll. B.M.[1] (Graham Wallas).

POLYZOA.
Fascicularia aurantium, M. Edwards. Coll. M.P.G., No. 398.
Cupularia canariensis, Busk. Coll. M.P.G., No. 399. B.M. (Graham Wallas).

ANNELIDA.
Ditrupa subulata, Deshayes, sp. Coll. M.P.G., No. 395.

CRUSTACEA.
[A decapod claw.] Coll. B.M. (Graham Wallas).
Balanus. Coll. M.P.G., No. 396.

ECHINODERMATA.
Temnechinus (?). Coll. B.M. (Graham Wallas).
Echinus woodwardi, Desor. Coll. M.P.G., No. 394. B.M. (Prestwich and Graham Wallas).
Dorocidaris papillata, Leske, sp. Coll. B.M. (Prestwich).

ACTINOZOA.
Trochocyathus (?). Coll. B.M. (Graham Wallas).

[1] The author desires to acknowledge his thanks to the authorities of the Museum of Practical Geology, and particularly to Mr. H. A. Allen, F.G.S., of that institution, for allowing him access to the "Reid" Collection. The letters B.M. and M.P.G. throughout this work apply respectively to the British Museum and the Museum of Practical Geology.

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In addition to these organisms the Lenham sandstones occasionally exhibit impressions of the spines of *Cidaris clavigera*, König, and remains of *Inoceramus*-shell associated with the sponge *Cliona*, all of which belong to the Chalk (Senonian) formation, and are consequently of derivative origin. No trace has been discovered in these beds of any fossils which could possibly have been derived from Eocene rocks.

BIBLIOGRAPHY (1857–1915).[1]

The history of the Lenham deposits and their fauna was commenced by the late Sir Joseph Prestwich in 1857,[2] when reporting the discovery by W. Harris and Rupert Jones of certain "blocks of gritty ferruginous sandstone, full of casts of shells", in some sand-pipes in the Chalk at Lenham, eight miles east of Maidstone, which they regarded as belonging to the basement-bed of the London Clay. Prestwich was familiar with similar sandstones occurring at Paddlesworth, near Folkestone, at a height of about 600 feet above sea-level, and at Vigo Hill near Otford in Kent, mentioning likewise that they were to be found in scattered fragments along the summit of the North Downs, extending from near Folkestone to Dorking in Surrey; but from the fossils he considered that the sandstones were of Lower Crag age, on account of the presence of a *Terebratula* resembling *T. grandis*, several species of *Astarte*, and a large *Lutraria*-like shell; this view being also shared by Searles Wood, who had examined the fossil remains, and recognized the importance of the occurrence of a *Pyrula* and an *Emarginula* as supporting that horizon. Prestwich also noted that beds of similar structure were present on the hills between Calais and Boulogne, at Cassel Hill near Dunkirk, and at Louvain and Diest in Belgium, besides thinking it possible that such sandstones were connected with the Carentan beds of Normandy.

In the following year Prestwich[3] again returned to the subject, aided by Searles Wood. He noticed that many of the species found at Lenham were of southern origin, thus confirming his previous ideas that the deposits were of Lower or Coralline Crag age. His determinations of the shells included the following forms:—

SCAPHOPODA.
Dentalium costata (?).

GASTROPODA.
Emarginula reticulata (?).
Nassa prismatica (?).
Scalaria subulata (?).
Pyrula.
Trochus.
Natica.
Rissoa (?).
Phorus, related to *Trochus cumularis*, Brong.

[1] The conchological determinations mentioned in the following memoirs are those of the authors themselves, without any attempt at a rectification of the nomenclature.

[2] "On some Fossiliferous Ironstone occurring on the North Downs": Quart. Journ. Geol. Soc., vol. xiii, pp. 212, 213, 1857.

[3] "On the Age of some Sands and Iron-Sandstones on the North Downs"; with a Note on the Fossils, by S. V. Wood: Quart. Journ. Geol. Soc., vol. xiv, pp. 322–35, 1858.

PELECYPODA.
Arca lactea (?).
Pecten avicula (?) and *P. bruei.*
Modiola modiola (?).
Pectunculus glycymeris (?).
Nucula nucleus (?).
N. depressa, Nyst.
Leda lanceolata and *L. myalis* (?).
Astarte digitaria, *A. pygmæa*, *A. compressa* (?), *A. omalii* (?).
Cardium (with spines) and *C. edule.*
Cytherea rudis (?).
Tapes perovalis.
Lutraria elliptica.
Crassatella concentrica (?), Duj.
Tellina donacina (?) or *Donax.*
Mactra triangulata (?).
Cardita, *Lucina* or *Diplodonta*, *Kellia* or *Lepton*, *Isocardia.*
Venus (?), *Anatina*, *Panopœa* (?).

BRACHIOPODA.
Terebratula grandis (?).

In the same memoir Prestwich referred to the occurrence of similar ferruginous sandstones to those at Lenham on the chalk downs between Calais and Boulogne, and at Cassel Hill in French Flanders, 515 feet above the sea, overlying the Calcaire Grossier series. It was mentioned that such beds, although without fossils, had been determined by Dumont and Lyell as equivalent to the Diestian Sands of Belgium, which they classed with the English Crag, because the same sands had been found at Louvain overlying the Limburg and Bolderberg strata, containing impressions of shells of *Terebratula grandis*, *Solen ensis*, and *Syndosmya prismatica*, besides thirteen genera of indeterminable species. In a further reference to the Lenham Mollusca, Searles Wood [1] mentioned that the *Pyrula* and *Pectunculus* resembled certain sandstone casts from the Red Crag (Box-stone specimens), although a closer determination was not possible from their peculiar preservation.

Lyell [2] recognized the Lenham Beds as of Upper Miocene or Falunian age, and similar to the Diestian Sands of Belgium, and, moreover, probably older than the Coralline Crag.

He had traced the Diestian beds, which "abound in green grains", from Diest by Louvain and Oudenarde to Cassel in French Flanders and capping the hills of those places—away to the English Downs near Folkestone, and appearing at such places as Paddlesworth, Lenham near Maidstone, etc. He referred to the occurrence in those beds of *Terebratula grandis*, casts of *Astarte*, *Pyrula*, *Emarginula*, which were all common to the British Crag, the first-named being specially characteristic of the Belgian Diestian.

As a result of an examination of the Prestwich Collection and that of the Geological Survey, Von Koenen [3] was of opinion that Lyell was wrong in his estimate of a Miocene age for the iron-sandstones of Kent, he regarding them as Pliocene because he considered they contained characteristic shells of the Upper Crag.

Mr. Whitaker [4] next gave his opinion on the age of the Lenham fauna, assisted by Gwyn Jeffreys in connexion with the molluscan

[1] "On the Extraneous Fossils of the Red Crag": Quart. Journ. Geol. Soc., vol. xv, pp. 32–45, 1859.

[2] *Elements of Geology*, 6th ed., pp. 233, 368, 1865.

[3] "Die Fauna der Unter-oligocänen Tertiärschichten von Helmstadt bei Braunschweig": Zeitsch. Deutsch. Geol. Ges., vol. xvii, p. 461, 1865.

[4] "On the Lower London Tertiaries of Kent": Quart. Journ. Geol. Soc., vol. xxii, p. 430, 1866.

determinations. Their results suggested an Eocene horizon, because among the fossils was identified a *Phorus* like *P. agglutinans*, *Cyrena cuneiformis*, and a small *Nucula* like *N. minor*.

Bristow[1] supported the Eocene age theory for the Paddlesworth ferruginous sands, which are unfossiliferous, and suggested that they belonged to the Woolwich and Reading series. In a postscript to this paper we are informed that the palæontologist W. H. Baily had examined Lenham fossils and pronounced them to be of London Clay origin.

In a later paper Von Koenen[2] regarded the ferruginous sandstones of Kent as corresponding with the Red Crag on account of the presence more particularly of *Arca lactea*, *Scalaria foliacea*, *Emarginula fissura*, and *Terebratula grandis*.

Writing on the "Box-stones" of East Anglia, Sir Ray Lankester[3] thought it very probable they were of the same age as the Lenham Sandstones; the former he considered as belonging to the Diestian series of Belgium, and approximately equivalent to the so-called Black Crag of Antwerp. The Belgian geologist Mourlon[4] next recognized that the "Sables de Diest" occurred on the North Downs of Kent, between Folkestone and Dorking, Paddlesworth, and Lenham near Maidstone, as first indicated by Prestwich and Lyell. Messrs. Cogels and O. Van Ertborn[5] alluded to Lyell's statement as to the abundant occurrence of *Terebratula grandis* in the ironstones of the North Downs, which was also found in the Diestian beds of Belgium, this horizon being considered of Lower Pliocene age and not Miocene as understood by Lyell.

A great advance in our knowledge of the Lenham deposits was next made by Mr. Clement Reid,[6] who regarded the beds as Older Pliocene of Coralline Crag age, and equivalent to the Lower Crag or Diestian of Belgium. He recognized that the St. Erth Beds were of similar age and not newer. Speaking of the Lenham Mollusca, he stated that *Arca diluvii* was new to England, and that *Pleurotoma consobrina* (?) and *P. jouanneti* (?) were species belonging to the Upper Miocene of the Continent. His list of determinations, endorsed by Messrs. Sharman and E. T. Newton, included 16 Gastropods, 21 Pelecypods, and 1 Brachiopod.

Four years later fuller particulars of the Lenham deposits were published by the same author[7] in a memoir on the British Pliocenes. They were alluded to as occurring in pipes of the Chalk formation,

[1] "Note on supposed Remains of the Crag on the North Downs near Folkestone": Quart. Journ. Geol. Soc., vol. xxii, p. 553, 1866.

[2] "On the Belgian Tertiaries": Geol. Mag., 1867, p. 502.

[3] "Contributions to a Knowledge of the Newer Tertiaries of Suffolk and their Fauna": Quart. Journ. Geol. Soc., vol. xxvi, pl. xxxiv, figs. 5–10, p. 499, 1870.

[4] *Géologie de la Belgique*, vol. i, p. 268, 1880.

[5] "Contribution à l'Étude des Terrains Tertiaires de la Belgique": Bull. Soc. R. Mal. Belgique, vol. xvii, pp. xliii–xlv, 1882.

[6] "The Pliocene Deposits of North-Western Europe": *Nature*, vol. xxxiv, pp. 341–3, 1886.

[7] *The Pliocene Deposits of Britain—Lenham Beds (Diestian)* (Mem. Geol. Surv.), 1890, pp. 2, 42–58, etc.

frequently at considerable heights above the sea, near Lenham itself being found at 680 feet above sea-level. The whole of the British Pliocene series were grouped into "Newer" and "Older", the latter containing the following divisions:—

OLDER PLIOCENE.

St. Erth Beds.	Lenham Beds.
Coralline Crag.	Box-stones.

In connection with the Lenham Mollusca it was stated that such southern genera as *Ficula* (*Pyrula*), *Xenophora* (*Phorus*), *Triton*, and *Avicula*, occurring in association with a profusion of *Arca diluvii*, *Cardium papillosum*, and some South European extinct species of *Pleurotoma* and *Terebra*, represented a fauna in favour of a southern or Mediterranean origin.

A full list of fossils from the Lenham and other Pliocene deposits of England was given in tabular order, showing the distribution of each species in Belgium, France, etc., the Lenham shells alone including 65 species, made up of 27 Gastropoda, 1 Scaphopoda, 36 Pelecypoda, and 1 Brachiopoda, as follows:—

GASTROPODA.
Actæon tornatilis, Linnæus.
Aporrhais pespelicani, Linnæus.
Buccinum dalei, J. Sowerby.
Cancellaria contorta, Basterot.
Cerithium tricinctum, Brocchi.
Cypræa europæa, Montagu.
Emarginula fissura, Linnæus.
Eulima subulata, Donovan (?).
Fissurella græca, Linnæus.
Margarita trochoidea, S. V. Wood.
Nassa prismatica, Brocchi.
Natica millepunctata, Lamarck.
N. varians, Dujardin.
Pleurotoma consobrina, Bellardi.
P. jouanneti, Desmoulins.
P. turrifera, Nyst.
Pyrula reticulata, Lamarck.
Ringicula ventricosa, J. Sowerby.
Scalaria clathratula, Adams.
Scaphander lignarius, Linnæus.
Terebra acuminata, Borson.
Triton heptagonum (?), Brocchi.
Trochus cinerarius, Linnæus.
T. millegranus, Philippi.
T. ziziphinus, Linnæus.
Turritella planispira, S. V. Wood.
Xenophorus sp.

SCAPHOPODA.
Dentalium dentalis (?), Linnæus.

BRACHIOPODA.
Terebratula grandis, Blumenbach.

PELECYPODA.
Arca diluvii, Lamarck.
A. lactea, Linnæus.
Artemis exoleta, Linnæus.
Astarte basteroti, Lajonkaire.
A. omalii, Lajonkaire.
A. galeottii, Nyst.
Avicula phalænoides (?), S. V. Wood.
Cardita senilis, Lamarck.
Cardium papillosum, Poli.
Cardium, n.sp.
Cyprina islandica, Linnæus.
Cytherea chione, Linnæus.
Diplodonta astartea (?), Nyst.
D. dilatata, S. V. Wood.
Donax politus, Poli.
Gastrana fragilis, Linnæus.
Hinnites cortesyi, Defrance.
Isocardia cor, Linnæus.
Leda semistriata (?), S. V. Wood.
Lepton deltoideum, S. V. Wood.
Lima loscombii (?), G. B. Sowerby.
Lutraria elliptica, Lamarck.
Mactra arcuata, J. Sowerby.
Nucula sulcata, Bronn.
Ostrea princeps, S. V. Wood.
Pecten maximus, Linnæus.
P. princeps, J. Sowerby.
P. varius, Linnæus.
Pecten, n.sp.
Pectunculus glycimeris, Linnæus.
Pholadidea papyracea, Solander.
Solen ensis, Linnæus.
Tellina benedeni, Nyst.
T. donacina, Linnæus.
Thracia pubescens, Pulteney.
T. ventricosa, Philippi.

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The next paper of importance was by Mr. F. W. Harmer,[1] in which the Lenham Beds were regarded as of older age than the Coralline Crag, on account of the more southern facies of the fauna, some of the molluscan species being characteristic of Miocene or Italian Lower Pliocene, which are unknown or rare in the Coralline Crag. The author included a distribution table of shells from the Belgian Diestian beds, showing the Lenham occurrence as well as those found in the "Box-stones" of Suffolk. In the following year the same author[2] referred the Lenham Beds to the Older Pliocene under the new horizonal term of "Lenhamian", and further recognized them in a classification table as belonging to the "zone of *Arca diluvii*", and of the age of the Diestian sands.

A more extended scheme of the Pliocene deposits of the East of England was again published by Mr. Harmer,[3] based on his classification table of 1899. In this the Older Pliocene beds were divided into:—

Len-hamian.	Lenham Beds:	Zone of *Arca diluvii*.	Diestian.
	Box-stones	Base of Red Crag. Base of Coralline Crag at Sutton.	Waenrode Beds (?).

The Coralline Crag deposits were scheduled as the basement of the Newer Pliocene series of rocks, which he had formerly placed in the Older Pliocene.

Mr. W. P. D. Stebbing[4] next announced the discovery of some molluscan remains in a patch of sand and ironstone at Netley Heath, Surrey, between Dorking and Guildford, along the top of the North Downs, at heights varying from 570 to 600 feet O.D. The specimens, consisting of sandstone casts, were referred to the genera *Cyprina* (?), *Modiola*, *Nassa*, *Trochus*, *Cardium*, *Pectunculus*, *Tellina*, and *Thracia*, no specific determinations being given. The author inclined to the view that these sandy deposits were a westerly extension of the Lenham Beds near Maidstone, and those at Paddlesworth north of Folkestone.

Referring to the Lenham fossils, which Mr. E. Van den Broeck[5] had examined at the Museum of Practical Geology, that author was of opinion that they represented a fauna of Diestian age. He noted the presence of older forms corresponding to the Bolderian (Upper Miocene) fauna of Belgium, and among the Box-stones at the Ipswich Museum he identified species found in the Belgium Miocene. He concluded, therefore, that the Lenham Beds were Diestian, and that the Box-stones corresponded with the Bolderian of Belgium, or

[1] "The Pliocene Deposits of the East of England; the Lenham Beds and the Coralline Crag": Quart. Journ. Geol. Soc., vol. liv, p. 308, 1898.

[2] "On a proposed new Classification of the Pliocene Deposits of the East of England": Rep. Brit. Assoc. (Dover), 1899, p. 752.

[3] "The Pliocene Deposits of the East of England, part ii: The Crag of Essex (Waltonian) and its Relation to that of Suffolk and Norfolk": Quart. Journ. Geol. Soc., vol. lvi, p. 708, 1900.

[4] "Excursion to Netley Heath and Newlands Corner": Proc. Geol. Assoc., vol. xvi, pp. 524–6, 1900.

[5] "Le Diestien et les Sables de Lenham, le Miocene démantelé et les Box-Stones en Angleterre": Bull. Soc. Belg. Géol. (Bruxelles) Procès-verbaux, vol. xvi, pp. 170–3, 1902.

DISTRIBUTION TABLE OF THE LENHAM MOLLUSCA AND BRACHIOPODA.

Genera and Species.	Geological Horizons.																		
	Aquitanian. 1	Burdigalian. 2	Vindobonian. 3	Redonian. 4	Messinian. 5	Box-stones. 6	Lenham Beds. 7	St. Erth Beds. 8	Coralline Crag. 9	Bolderian. 10	Anversian. 11	Diestian. 12	Scaldisian. 13	Plaisancian. 14	Astian. 15	Red Crag. 16	Norwich Crag. 17	Post-Pliocene. 18	Recent. 19
GASTROPODA—																			
Capiluna græca, Linnæus, sp. . .			x	x			x		x				x			x			x
Emarginula fissura, Linnæus, sp. .				x			x		x		x		x	x	x	x			x
Eumargarita trochoidea, S. V. Wood, sp.							x						x			x		x	x
Calliostoma zizyphinum, Linnæus, sp.						x	x	x	x			x	x			x			x
Ampullotrochus miliaris, Brocchi, sp.			x		x		x	x	x		x			x	x				x
Capulus ungaricus, Linnæus, sp. .			x	x			x	x	x			x	x			x		x	x
Trivia europæa, Montagu, sp. . .			x	x			x	x	x		x	x	x	x	x	x		x	x
Ptychopotamides tricinctus, Brocchi, sp.			x	x			x	x					x	x	x	x	x	x	
Scala subulata, J. de C. Sowerby, sp.							x		x			x	x			x			(?)
Hyaloscala clathratula, Kanmacher, sp.				x			x		x			x	x						x
Pyramidella plicosa, Bronn, sp. .			x		x		x		x		x			x	x	x			
Subularia subulata, Don., sp. . .			x		x		x	x	x		x	x	x	x	x				x
Zaria subangulata, Brocchi, sp. .			x		x		x	x	x		x			x	x				
Xenophora crispa (?), König, sp. .							x							x	x				
Aporrhais pespelecani, Linnæus, sp. .			x				x		x		x	x	x	x	x	x	x	x	x
Semicassis saburon, Brug., sp. . .			x		x	x	x				x		x	x	x	x			x
Ficus reticulata, Lamarck . .			x	x	x	x	x		x	x	x	x		x	x	x			x
Streptochetus sexcostatus, Beyrich, sp.			x		x		x				x								
Tritia limata, Chemnitz, sp. . .		x	x	x	x		x		x		x		x	x	x				x
Murex badensis, Nyst . . .			x				x		x				x			x			
Boreotrophon clathratum, Linn., sp.							x		x	x						x	x	x	x
Trophonopsis muricatus, Montagu, sp.				x			x						x			x		x	x
Bonellitia serrata, Bronn, sp. . .			x				x							x					
Maculopeplum lamberti, J. Sow., sp.			x	x		x	x		x			x	x			x			
Turris turrifera, Nyst, sp. . .			x		x		x			x	x	x	x	x	x	x		x	
Drillia obeliscus, Des Moul., sp. .		x	x		x		x			x	x	x							
Clavatula jouanneti, Des Moul., sp. .		x	x				x												
Terebra acuminata, Borson . .			x		x		x				x			x	x				
Actæon tornatilis, Linnæus, sp. .			x		x		x		x		x	x	x	x	x	x	x		x
Ringiculella lenhamensis, sp.n. .							x												
Scaphander lignarius, Linnæus, sp. .			x	x	x		x		x	x	x	x	x	x	x	x			x
Bullinella cylindracea, Pennant, sp.			x	x	x		x		x		x	x	x	x	x	x			x
SCAPHOPODA—																			
Dentalium entale, Linnæus . .			x		x	x	x				x	x	x	x			x	x	x
PELECYPODA—																			
Nucula proxima, Say							x	x	x		x							x	x
Nucula cf. *sulcata*, Bronn . .			x				x	x						x	x				x
Yoldia oblongoides, S. V. Wood, sp. .							x									x	x	x	

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DISTRIBUTION TABLE—(*continued*).

GENERA AND SPECIES.	GEOLOGICAL HORIZONS. Aquitanian. 1	Burdigalian. 2	Vindobonian. 3	Redonian. 4	Messinian. 5	Box-stones. 6	Lenham Beds. 7	St. Erth Beds. 8	Coralline Crag. 9	Bolderian. 10	Anversian. 11	Diestian. 12	Scaldisian. 13	Plaisancian. 14	Astian. 15	Red Crag. 16	Norwich Crag. 17	Post-Pliocene. 18	Recent. 19
PELECYPODA (*continued*)—																			
Monia patelliformis, Linnæus, sp.							x		x					x	x	x	x	x	x
Anadara diluvii, Lamarck, sp.			x		x		x			x	x			x					
Fossularca lactea, Linnæus, sp.			x	x			x		x					x	x	x		x	x
Glycymeris pilosa, Linnæus, sp.			x	x	x	x	x	x	x		x	x	x		x				x
Mytilus edulis, Linnæus, var. *ungulatus*, Poli							x									x			x
Volsella barbata, Linnæus, sp.							x							x		x			x
Margaritifera phalænacea, Lamarck, sp.	x	x	x				x		x		x			x					
Ostrea princeps, S. V. Wood							x		x			x	x			x			
Pecten maximus (?), Linnæus, sp.							x	x	x		x	(?)	x			x			x
Æquipecten opercularis, Linnæus, sp.					x	x	x	x	x			x	x	x	x	x	x	x	x
Manupecten pesfelis, Linnæus, sp.			x	x			x							x	x				x
Chlamys princeps, J. de C. Sow., sp.							x		x				x				x		
Hinnites crispus, Brocchi, sp.					x	x	x		x					x	x	x			
Glans senilis, Lamarck, sp.			x	x			x		x				x			x			
Astarte basteroti, Lajonkaire				x			x		x			x	x			x			
A. galeottii, Nyst							x		x				x			x			
A. omalii, Lajonkaire			x	x			x		x	x	x	x	x			x		x	
A. mutabilis, S. V. Wood							x		x		x		x			x			
Cyprina rustica (?), J. Sowerby, sp.			x		x	x	x		x		x	x	x			x			
Isocardia humana (=*cor*), Linn., sp.			x				x		x			x				x			x
Dentilucina borealis, Linnæus, sp.			x	x	x		x	x	x		x	x	x	x	x	x	x	x	x
Arcopagia ventricosa, Serres, sp.			x				x							x	x				
Tellina benedeni, Nyst & West			x		x		x			x	x	x	x			x			
Moera donacina, Linnæus, sp.			x				x		x				x	x	x	x		x	x
Gastrana laminosa, J. de C. Sow., sp.							x		x				x			x			
Spisula arcuata, J. Sowerby, sp.							x			x		x	x			x	x	x	
S. subtruncata, Da Costa, sp.			x	x		x	x	x	x				x	x	x	x	x	x	x
Pitar rudis, Poli, sp.			x	x			x		x				x	x	x	x		x	x
Callista chione, Linnæus, sp.			x	x			x		x	x	x	x	x	x	x	x			x
Tapes perovalis, S. V. Wood							x		x										
Papillicardium papillosum, Poli, sp.			x	x	x		x	x						x	x				x
Plagiocardium hirsutum, Bronn			x				x							x	x				
Ensis ensis, Linnæus, sp.			x	x			x	x	x		x	x	x	x	x	x		x	x
Cyrtodaria angusta, Nyst & West, sp.					x	x	x		x	x	x	x	x			x			
Panopæa menardi, Deshayes			x		x	x	x		x		x					x			
Barnea cylindrica, J. Sowerby, sp.							x									x			
Aspidopholas rugosa, Brocchi, sp.							x							x	x				
Pholadidea papyracea, Turton, sp.				x			x		x		x	x							x
Thracia convexa, W. Wood			x			x	x		x					x	x			x	x
T. pubescens, Pulteney, sp.			x				x		x				x	x	x			x	x
BRACHIOPODA—																			
Terebratula perforata, Desnoy				x			x		x	x	x	x	x			x			

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probably a more recent horizon which represented the Mio-Pliocene or Older Pliocene, a period slightly anterior to the Diestian. He was also of opinion that the zones of *Terebratula grandis* and *Isocardia cor* could not be separated, but belonged alike to the Diestian division of the Pliocenes.

In a further contribution, Mr. Harmer[1] regarded the Lenham Beds as synchronous with the ferruginous sandstones of Louvain and Diest. He stated that among the Diestian sandstone fossils were about sixty species of Mollusca, some being Crag forms, whereas a few were of an older or Miocene type and not found in the Coralline Crag; similarly the Lenham shells included many Miocene species, such as *Terebra acuminata*, *Triton heptagonum*, *Pleurotoma consobrina*, *P. jouanneti*, *Cancellaria contorta*, *Hinnites cortesyi*, and *Arca diluvii*. A table of the British Pliocene deposits was included, being nearly similar to that issued by the same author in 1900, in which the "Lenhamian" formed the lowest of the Pliocene stages, the Box-stones being regarded as equivalent to the Waenrode Beds of Belgium (Bolderian, according to Mr. Van den Broeck).

Subsequently Mr. Harmer[2] repeated his former views on the age of the Lenham deposits, the fauna being spoken of as presenting a distinctly older type than that of the Coralline Crag and approaching more nearly a Miocene facies, instancing, among other shells, the abundance of *Anadara diluvii*, which occurs in the Vienna Basin, the Touraine area of France, and the Bolderian of Belgium.

In their memoir on the geology of Holland, Messrs. G. A. F. Molengraaff and A. J. M. Van Waterschoot Van der Gracht[3] referred to the occurrence of *Anadara diluvii* in the Lenham Beds as indicative of a Miocene age, the same shell being found in the Miocene deposits of Peel and Winterswyk in Holland, the rocks of the former place being stated as the equivalent of the "Glimmertons" of the north of Germany or the Tortonian stage of the Miocene, whilst the beds at Winterswyk were regarded as Middle Miocene. This work also included lists of molluscan species from the Upper and Middle Miocene deposits of Holland, many of which are found in the Lenham Beds.

Another reference to the geological aspect of this subject has been made by Mr. F. W. Harmer[4] in an "Introduction" to a new work on British Pliocene Mollusca, where he adheres to his previously expressed views that the Lenham Beds with the "Box-stones" and the Belgian Diestian deposits should be grouped as Lower Pliocene and that the Coralline Crag beds of East Anglia should form the base of the Upper Pliocenes.

A final notice to make involves a slight alteration in the views of Mr. C. Reid,[5] who, in a work recently published, places the Coralline

[1] "A Sketch of the Later Tertiary History of East Anglia": Proc. Geol. Assoc., vol. xvii, pp. 416–79, 1902.

[2] "The Pliocene Deposits of the Eastern Counties of England": Geol. Assoc., Jubilee Volume, 1908, pp. 86–102.

[3] "Niederlande": Handb. Region. Geol., vol. i, pt. iii, pp. 51–3, 1913.

[4] *The Pliocene Mollusca of Great Britain* (Mon. Pal. Soc.), 1914, pt. i, p. 5.

[5] C. & E. M. Reid, "The Pliocene Floras of the Dutch-Prussian Border": Mededeel. Rijks. Delfst., 1915, No. 6, p. 9.

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Crag and Lenham Beds in the Lower Pliocene group, bracketing them as equivalent to the Diestian—but the "Box-stones" are scheduled as Miocene.

(*In July will follow Mr. Newton's conclusions.*)

II.—The Horizon of the Type-specimens of Dr. Scouler's *Dithyrocaris tricornis* and *D. testudinea*. By Peter Macnair, F.R.S.E., F.G.S.[1]

Introduction.

THE exact locality and as a consequence the precise geological horizon from which the type-specimens of *Dithyrocaris tricornis* and *D. testudinea* were obtained has long been a matter of considerable uncertainty. These type-specimens, now preserved in Kelvingrove Museum, were first described by Dr. John Scouler in the *Records of General Science* for the year 1835 (p. 137). The object of this paper is to demonstrate that these fossils came from what was known as the Gallowhill Quarries, and that they occupy a position near the top of the Blackbyre Limestone of this district.

Regarding the beds in which they were found Dr. Scouler says: "This limestone is situated about a mile to the east of Paisley, and was first pointed out to me by Mr. Murray, of the Glasgow Botanic Gardens. This rock is distinct from and probably reposes on the true Carboniferous Limestone, but as only a small patch of it is exposed, the greater part being covered by the soil, it was impossible to trace its relations with the subjacent strata. This limestone is of an extremely compact nature, with little plates of calcareous spar disseminated through its substance. It readily splits into flags of variable thickness, which are sometimes made of a multitude of extremely thin layers, indicating that the whole stratum has been formed by the gradual and tranquil deposition of transported matters. The organic matters differ widely from those which we observe in the Carboniferous Limestone. I could detect no *Productidæ* nor any fragments of corals or stems of crinoid animals, nor, in short, any decidedly massive production. Instead of these, on splitting up the rock we observe impression of ferns of great variety and beauty, the remains of entomostraca, which are of gigantic size when compared with the analogous species which still abound in our lakes and pools. Two species belonging to a new genus were obtained, and the numbers might have been greatly increased had not the hardness of the rock rendered the extraction of the specimens a difficult task." It will be noted that though in the above account no definite locality is mentioned, yet they are recorded as coming from a locality about a mile to the east of Paisley. Another important feature of this account is that it is such an exact description of the nature of the limestone in which the fossils occur that we can have no hesitation in identifying it with the bed to be described subsequently in this paper.

[1] Reprinted in a slightly abridged form from the Transactions of the Geological Society of Glasgow, vol. xvi, pt. i, 1915–17.

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In the *New Statistical Account of Scotland*, published in 1845, under the section "Town and Parishes of Paisley", we find the following important reference to this limestone and these fossils (1845, p. 157). It is of very great interest, because it appears to have hitherto escaped notice, and because it cites the Farm of Gallowhill as the exact locality where the fossils were obtained. The reference runs as follows: "To the north-east of Paisley, on the Farm of Gallowhill, a quarry has of late been wrought in an extensive bed of schistose rock lying almost horizontally about 3 feet below the surface. Its colour is dark grey approaching to black. Its texture is compact and fine grained, and it readily splits into layers, but is with difficulty broken across. The fracture is splintery and rather conchoidal. It is composed of about 32 per cent. of carbonate of lime, 47 of sand, and 9 of alumina. This rock abounds in beautiful specimens of many genera and species of ferns, as also of shells, chiefly Terebratula, Nucula, and Orthoceratites. The layer of till immediately above this rock for several inches closely resembles Fuller's earth." The most interesting point, however, bearing upon the locality from which Scouler obtained his fossils is contained in the following footnote, which is added: "Two species found here belonging to a rare genus are described by Dr. Scouler in Thomson's Records of General Science, vol. i."

In 1865 Mr. James Armstrong (1865, p. 74) states in a paper published in the *Transactions* of this Society that specimens of *Dithyrocaris* were obtained by Dr. Scouler upwards of thirty years ago in a limestone excavated for the foundations of the Paisley Barracks.

In a paper read to the Society in 1893 Mr. James Neilson (1893, p. 71) makes the following statement regarding the locality where the type-specimens of *Dithyrocaris tricornis* and *D. testudinea* were found: "It is worthy of notice that when the late Dr. Scouler first discovered *Dithyrocaris* at Inkerman, near Paisley, nearly the entire animal was got. These beds were afterwards lost, and during many years since, the finding of only one or two carapaces has been recorded." From this it will be seen that Mr. Neilson, in utter disregard of any of the foregoing statements as to the locality at which the specimens were got, has shifted it to Inkerman, 1½ miles west of Paisley. But he gives us no reason for his doing so, and I am utterly unable to understand upon what grounds it was made.

In their memoir on the British Palæozoic Phyllocaridæ Professor T. Rupert Jones and Dr. Henry Woodward (1898, p. 147) still further complicate the matter, for in the text they say that Dr. Scouler's original specimen of *Dithyrocaris testudinea* is in hard, black, earthy limestone from the Carboniferous Limestone Series about a mile to the east of Paisley, the latter part of the sentence being quoted from Dr. Scouler's paper. But in a footnote they say, "At a place now called Inkerman, where Mr. R. Dunlop has lately most obligingly sought for further indications of these fossils, but without success." In this footnote they have evidently been misled by Mr. Neilson.

As we have already said, we hope to show that the statement made by the authors of the *Statistical Account* is probably the correct one, and that the specimens were got in a peculiar limestone which was formerly quarried on Gallowhill Farm, 1½ miles to the north-east of Paisley, and that both Mr. Armstrong's and Mr. Neilson's statements as to the locality where they were found are erroneous.

THE TYPE-SPECIMENS OF *DITHYROCARIS TRICORNIS* AND *D. TESTUDINEA*.

The type-specimens of the two species of *Dithyrocaris* were originally presented to the Anderson College Museum by Dr. Scouler, and some years ago were gifted, along with other specimens, to Kelvingrove Museum by the Governors of the Royal Technical College. *D. tricornis* shows the two valves of the carapace lying in an almost symmetrical position, but reversed so that the anterior part is approximately in the position that the posterior part ought to be, a phenomenon not unusual in decaying and floating Phyllopods.

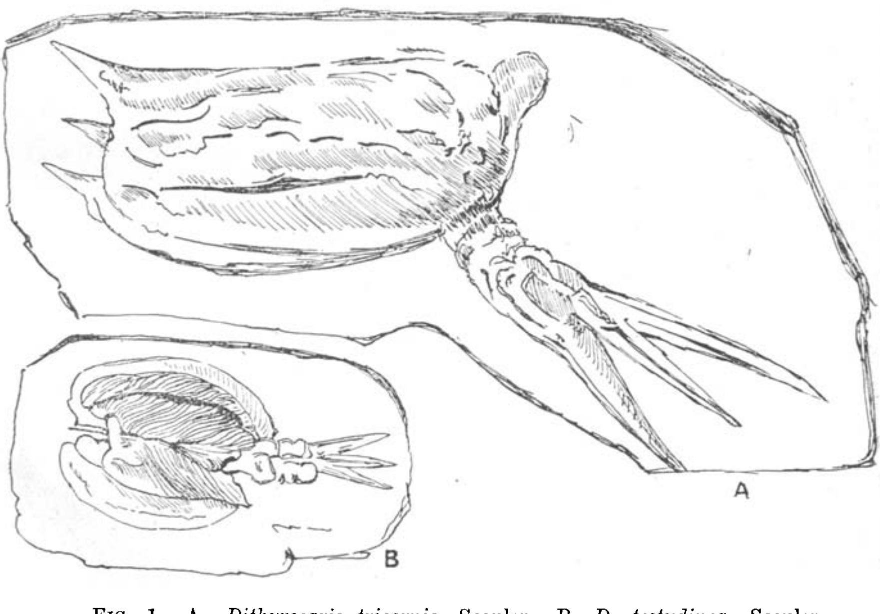

FIG. 1.—A. *Dithyrocaris tricornis*, Scouler. B. *D. testudinea*, Scouler. From the original drawings in Scouler's paper. The type-specimens are now in Kelvingrove Museum.

The three somewhat obscure abdominal segments and a tail with three spines project from the lower part of the front of the carapace. The gastric teeth are exposed through the test.

In *Dithyrocaris testudinea* the broad oval carapace is semi-elliptical in shape. The two valves lie in opposition by their dorsal edges, and overlap irregularly towards the lower half of the dorsal region. In both valves the central border is seen to terminate in a small obscure spine. A strong ridge showing the characteristic rugose structure of the overlapping chevron-shaped scales runs down the

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middle of each valve. The abdominal segments which project from behind the carapace have been considerably crushed. The three caudal spines are well shown. They are of nearly equal length, stout, fluted, and show traces of granulation on the riblets. Fig. 1, which shows *Dithyrocaris tricornis* and *D. testudinea*, is after the original drawing in Dr. Scouler's paper.

The only other fossil preserved on the slabs containing the type-specimens is a single specimen of *Lingula mytiloides*, which is seen on the large slab with *Dithyrocaris tricornis.* As we shall presently see, this is the commonest of all the fossils found in the Gallowhill Limestone, in which it is often exceedingly numerous.

THE GALLOWHILL LIMESTONE.[1]

About two years ago my attention was first directed to the peculiar character of the limestone that forms the wall to the east of Gallowhill, near Paisley. The locality from which Scouler's type fossils had been obtained had for a long time exercised my mind, as it had done that of other local geologists, and when I first saw the limestone of which the wall is built I was at once struck with its strong similarity to that forming the matrix of the Scouler fossils. I took a specimen of the limestone with me, and a comparison of it with the specimens in the museum at once confirmed their identity. Both present the same earthy-like appearance, their joint faces being lined with calcite, and strongly charged with iron pyrites in nodular masses and in strings and isolated cubes. Associated with the limestone are bands of a much more argillaceous and sandy nature, of which examples may be seen in the dykes and bings, the large bing to the south of Gallowhill House having yielded numerous examples of the different types of sedimentation that appear to have prevailed upon this horizon. I am indebted to Mr. R. S. Houston for the following analysis of the limestone, which, like the analysis given in the *Statistical Account*, shows that it contains a large percentage of siliceous and clayey matter:—

Carbonate of lime	48·67
Carbonate of magnesia	·98
Carbonate of iron	5·70
Alumina	1·02
Siliceous matter (clay)	40·23
Carbonaceous matter	2·30
Moisture	·57
	99·47

After convincing myself of the lithological identity of the two limestones I began to search for some evidence of a Phyllopod fauna, and was soon rewarded by clear evidence of its presence. Nothing to equal Scouler's specimens has yet been found, but fragments of carapaces and tail spines are sufficiently numerous and in a similar state of preservation to conclusively demonstrate the identity of the

[1] It should be clearly understood that the local term "Gallowhill Limestone" used throughout this paper does not stand for any new limestone horizon, but is only used to express a peculiar phase occurring at the top of the Blackbyre Limestone. This, indeed, is the main object of the paper.

Gallowhill Limestone with that which forms the matrix in which Scouler's fossils are preserved. The most abundant fossil in the Gallowhill Limestone is *Lingula mytiloides*, many of the slabs being simply crowded with them. The full significance of the faunal association found in the Gallowhill Limestone will, however, be discussed in more detail presently. In his paper Scouler refers to the absence of Productidæ, corals or stems of crinoid animals, but *Productus longispinus* and *Rhynchonella pleurodon* are fairly abundant on some slabs. Slabs of the limestone rich in crinoidal remains have also been observed. But whether these represent the same bed as that which carries the Phyllopod fauna or one on a slightly different horizon we have not yet been able to determine definitely, but we are inclined to favour the latter view.

Arkleston Cutting and Former Exposures at Gallowhill.

In my paper on the Hurlet sequence in North Ayrshire I have given an account of the strata exposed in the Arkleston Cutting, and it is there shown that the top limestone is the Hurlet Limestone, here 3 to 4 feet thick and dipping towards the east. Below it comes the Hurlet Alum Shale, only some 6 inches thick, followed by the Hurlet Coal, originally from 5 to 6 feet thick. The coal has been split up the centre by a sill of dolerite, some 80 feet in thickness, lenticles of the coal occurring within the sill. Below the sill comes some 18 feet of shale and fireclay, in which there is a limestone in three seams full of entomostraca and fish remains, and which is clearly the equivalent of the Baldernock Limestone of the Campsie district. The whole group of sedimentary strata is much pyritized and altered by contact with the intrusive sill of dolerite. A search for the alum shale fauna in the fragments that are seen to lie above the sill has not as yet been successful in yielding any examples of that characteristic fauna, as the shale is very completely baked. But the discovery of the fauna at this point is not yet regarded as entirely hopeless. I have also shown in the paper mentioned that a highly fossiliferous limestone was at one time exposed between the bridge and the signal box, and that, dipping towards the east, it passed beneath the strata in the cutting just described. A consideration of all the available palæontological and stratigraphical evidence goes to show that this limestone must have been the equivalent of the Blackbyre Limestone.

If we turn to the 6-inch-to-the-mile Geological Survey map, of which Fig. 2 is in part a reproduction, it will be noticed that the limestone, there shown as trending northwards towards the Arkleston Print Works, and then bifurcating into two outcrops towards the north-west, clearly lies below the sill now seen in the cutting. When the Geological Survey map was made in the year 1875 the railway ran through a tunnel at this point, and the Hurlet Limestone lying above the sill does not appear to have been exposed. If it was it is not indicated on the map. The limestone represented on the map is drawn as two narrow outcrops at the Paisley end of the tunnel. Unfortunately no exposure can now be observed between the bridge over the railway and the signal box. But that a limestone was at

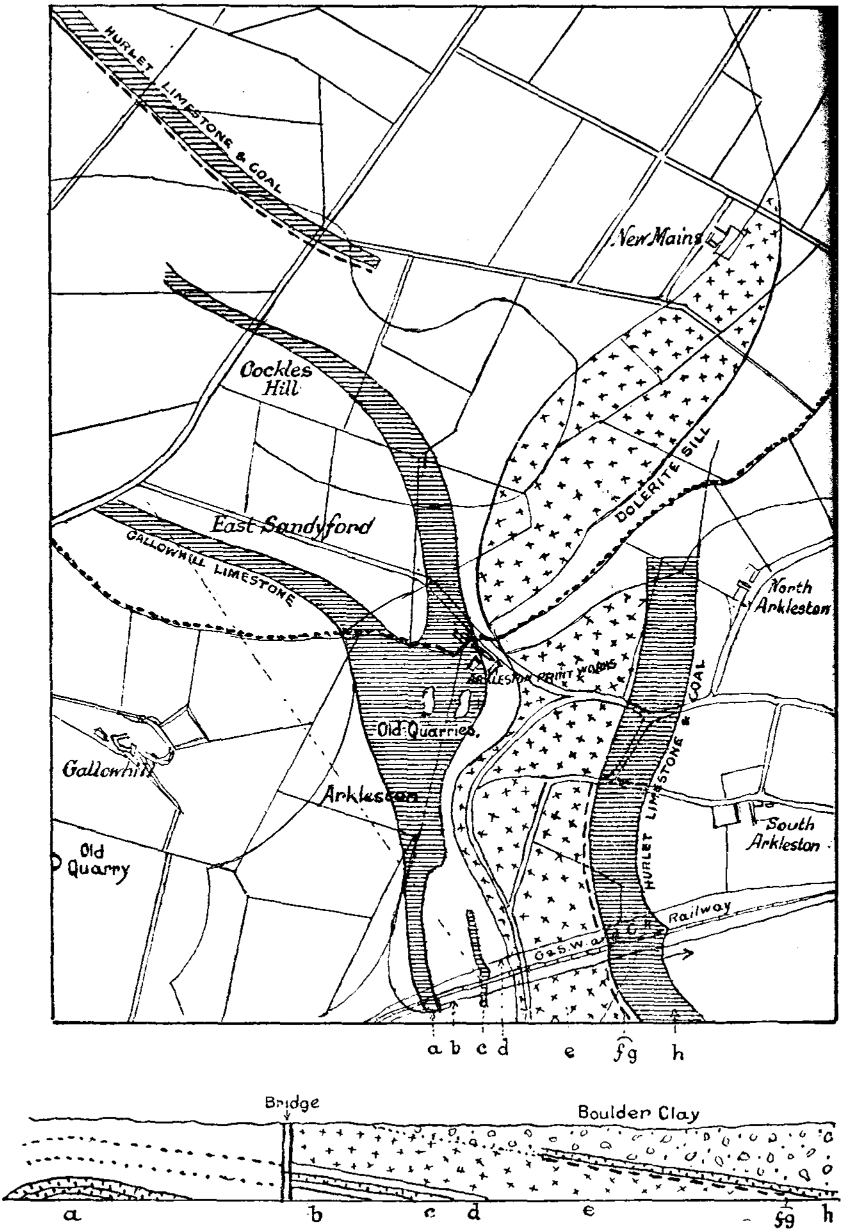

FIG. 2.—Sketch-map and section along the railway at Arkleston, Paisley. *a*, Blackbyre Limestone with Gallowhill Limestone phase at top; *b*, Cementstone with rootlets; *c*, Entomostracan Limestone; *d*, shales and fireclay; *e*, dolerite sill; *f*, Hurlet coal; *g*, alum shale; *h*, Hurlet Limestone.

one time exposed at this point is made clear both by the Survey map and by Mr. Blair's paper published in our Transactions (1889, p. 133). In this paper Mr. Blair describes it as exhibiting "a wider variety and more abundant quantity of delicate organisms than I have yet seen in any of these deposits".

The section between the railway bridge and the signal box at the Paisley end of the cutting is now so completely grassed over that not a vestige of rock can now be seen, and we are left to judge by analogy with the general sequence of the district what the horizon of the limestone formerly exposed at this point may be. Fortunately, though exposures are extremely rare upon this horizon in this district, yet the cumulative evidence is such as to leave no room for any doubt in our minds that the limestone formerly exposed at this point, known locally as the Gallowhill Limestone, must be the equivalent of the Blackbyre Limestone of the Hurlet type section. On the east side of the railway bridge the lowest bed seen in the railway cutting is a band of grey cement limestone with rootlets, which all over this area is a well-marked horizon lying immediately below the Hurlet Coal and above the Blackbyre Limestone. It can be seen at Crookston Farm cropping from below the dolerite sill in exactly the same fashion as it does in this cutting, but there in addition to the rootlets it contains fish teeth, *Spirorbis*, and entomostraca.

Below this rooty cementstone there comes in the Hurlet district a variable thickness of shales succeeded by the Blackbyre Limestone. This view has been expressed in the section in Fig. 2; *a* is the Gallowhill Limestone, being the top of the Blackbyre Limestone, shown as folded into a gentle arch, which gives off in its eastern limb, *b* the cement limestone with rootlets, *c* thin bands of limestone with entomostraca and fish remains, *d* beds of shale and fireclay, *e* intrusive sill of dolerite, *f* and *g* Hurlet Coal and alum shale, and *h* Hurlet Limestone.

As has already been stated, no exposures of the Gallowhill Limestone can now be seen at any of the localities where it was formerly worked. But the position of two of the quarries south of the Arkleston Print Works can still be seen. Another quarry appears to have been opened a little to the south of Gallowhill, opposite the Mote Hill. The positions of these quarries are indicated on the map, and they seem to have been somewhat extensively worked about the year 1835, when Scouler's fossils were found, the old Powder Magazine between Arkleston and South Arkleston having been built of it, as well as a large number of the dykes in the Gallowhill Policies. It was also used in some walls in the neighbourhood of the Paisley Barracks, where it can still be seen. This may have something to do with Armstrong's statement that Scouler's fossils were found in a limestone excavated for the foundations of the Paisley Barracks.[1] That the Gallowhill Limestone must extend considerably

[1] Since writing this paper I have been informed by Mr. R. Houston that in making the foundations for the villas adjoining the Paisley Barracks it was found that slabs of the Gallowhill Limestone had been used to fill up old hollows in the surface of the ground.

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to the west of the outcrop, as drawn on the map, is made clear both from the evidence derived from the old quarry opposite the Mote Hill and also from recent information that we have obtained which shows that Gallowhill House rests upon it. But whether it is continuous over this area or is repeated by faulting we have no data to decide, and the position of the outcrop is left much as it is given in the 6-inch-to-the-mile Geological Survey map.

The statement in the *Statistical Account* that the layer of till immediately above the Gallowhill Limestone for several inches closely resembles fuller's earth is of great interest, as we seem to recognize in this the peculiar ashy fireclay which is generally found to rest on the eroded top of the Blackbyre Limestone of Renfrewshire and North Ayrshire.

In interpreting the structure of the ground between Arkleston and the Cart it seems to us that there must be a low arch bringing in the strata that lie immediately below the Hurlet Limestone. On the east this arch sinks below the Hurlet Limestone, as exposed in the Arkleston Cutting, and on the west it must pass below the outcrop of the Hurlet Limestone and Coal which has been drawn by the Survey to cross the White Cart Water near Carlisle Quay and Nethercommon. An exposure of limestone underlaid by a bed of coal with pyrites can at present be seen at low tide immediately below the Swing Bridge at Carlisle Quay, but owing to the limited nature of the exposure it is at present difficult to determine whether this is the Hurlet Limestone or the Blackbyre Limestone, but it is certainly the equivalent of one of these.

Bores put down along the outcrop of the dolerite on the Gallowhill Policies show that the dolerite rests along this line upon a series of thick-bedded shales, fireclays, and sandstones which have been bored into for a depth of more than 30 fathoms. There can scarcely be any doubt that the uppermost of these represent the sediments which lie between the Blackbyre Limestone above and the Hollybush Limestone below. On the 6-inch-to-the-mile Geological Survey map a bore put down to the south of Gallowhill shows the presence of a coarse limestone 1 ft. 7 in. thick at a depth of 12 fathoms. This is probably upon the position of the Hollybush Limestone.

Comparison with the Blackbyre Limestone at other Localities.

From the evidence that has been adduced there can be no doubt that the Gallowhill Limestone must lie somewhere on the horizon of the Blackbyre Limestone, and we now pass to consider the evidence that exists bearing upon the lithological and palæontological characteristics of the Blackbyre Limestone in this district. At the type locality (Blackbyre Farm) the Blackbyre Limestone consists of two parts, a lower full of small Brachiopods, largely *Productus longispinus*, and an upper part which is crinoidal. Neither of these, however, can be compared with the Gallowhill Limestone. As a rule, the Blackbyre Limestone of this district may be described as essentially a Brachiopod or shelly limestone with occasional bands of *Lithostrotion.* The contention of this paper is that the Gallowhill

Limestone is simply a phase characteristic of the top of the Blackbyre Limestone, and as the top of the limestone is not seen at the type locality it is quite possible that it may be present though not exposed.

The section exposed at Jenny's Well, a quarter of a mile to the east of Blackhall, Paisley, is practically a counterpart of that seen in the Arkleston Cutting, and the additional corroborative evidence bearing upon the relationship of the Gallowhill Limestone to the Blackbyre Limestone is so complete that it requires to be examined in some detail. The section shows a fairly continuous sequence from the Blackhall Limestone down to the base of the sill of dolerite which here occupies exactly the same stratigraphical position as in the Arkleston Cutting, having the Hurlet Limestone above and the Blackbyre Limestone below.

Unfortunately the outcrop of the Blackbyre Limestone cannot be seen, but its position is shown by a hollow immediately to the west of the dolerite sill, which runs in a north and south direction from the Cart up the side of Dykebar Hill, marking the line along which it was formerly quarried. Just at the point where the road crosses the railway the Blackbyre Limestone was exposed during the making of the line. It cannot now be seen, but the walls on each side of the railway at this point are built of it, and the blocks of limestone show all the features of the Gallowhill Limestone on the one hand and of the Blackbyre Limestone of the type section on the other.[1]

An examination of the exposure of the Blackbyre Limestone seen in the bed of the Levern at Neilston, a little above the point where it crosses the main road to Lugton, helps, we think, to throw some light upon the relationship of the Gallowhill Limestone to the Blackbyre Limestone. The section here is somewhat obscure, but the main mass of the limestone is rich in corals and Productidæ. The former are represented by bands of *Lithostrotion* and solitary corals, the latter by various species of *Productus* and by numerous specimens of the large variety of *Productus giganteus*. On the top of the main mass of the limestone rests a bed of fine-grained cementstone, which presents all the features of the Gallowhill Limestone. Traced into North Ayrshire, it forms the peculiar fine-grained top of the Dockra Limestone and its equivalents, which we have elsewhere shown to be the same as the Blackbyre Limestone of the Hurlet section.

An examination of the sections exposed in the burn at Meikle Corseford, and on the Gryffe Water below Bridge of Weir, also affords certain evidence which goes to confirm the relationship of the Gallowhill Limestone to the Blackbyre Limestone. At both localities the Blackbyre Limestone is capped by a fine-grained crinoidal limestone comparable to the crinoidal phase of the Gallowhill Limestone. And at both these localities it is overlaid by the peculiar green ashy mud which is probably identical with the so-called fuller's earth found in the Gallowhill Quarry.

[1] The evidence derived from these blocks shows that the Blackbyre Limestone of this locality has a strong resemblance to that exposed in the Beith Quarries. It carries a varied Brachiopod fauna and contains thick bands of *Lithostrotion* and other corals.

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THE FAUNAL ASSOCIATION OF THE GALLOWHILL LIMESTONE.

The fauna of the Gallowhill Limestone is an exceedingly characteristic one, and has a remarkable resemblance to that which exists on a much higher stratigraphical horizon, the Calderwood Cementstone of the East Kilbride district. So striking is the similarity between the two that we here institute a comparison between them to show that they must have been accumulated under closely similar physical conditions. Both in the Calderwood Cementstone and the Gallowhill Limestone the fossils are but sparingly distributed throughout the limestone, and the rarer forms only occur at wide intervals. The following list gives some of the principal species that occur in the Calderwood Cementstone at such localities as Burnbrae, Jackton Burn, Kirktonholm, Glebe Quarry, and Limekilns House.

Serpulites carbonarius, M'Coy.	*Lingula squamiformis*, Phill.
S. membranaceus, M'Coy.	*Productus semireticulatus*, Mart.
Spirorbis caperatus, M'Coy.	*P. longispinus*, Sow.
Dithyrocaris glabra, Woodw. & Eth.	*Rhynchonella pleurodon*, Phill.
D. granulata, Woodw. & Eth.	*Streptorhynchus crenistria*, Phill.
D. ovalis, Woodw. & Eth.	*Aviculopecten knockonniensis*, M'Coy.
D. testudinea, Scouler.	*Posidonomya corrugata*, Eth.
D. tricornis, Scouler.	*Nuculana attenuata*, Flem.
Palæmysis, Peach.	*Protoschizodus æquilateralis*, M'Coy.
Palæcrangon, Salter.	*Nucula gibbosa*, Flem.
Palæsquilla Pattoni, Peach.	*Sanguinolites plicatus*, Portl.
Anthrapalæmon Coutsii, Peach.	*Orthoceras attenuatum*, Flem.
Discina nitida, Phill.	*Nautilus* sp.

Serpulites carbonarius occurs in the Calderwood Cementstone, some slabs being simply covered with the tubes of this worm. In the Gallowhill Limestone they occur in exactly similar conditions. I have also found traces of *Serpulites membranaceus* and *Spirorbis caperatus* in the Gallowhill Limestone.

The Phyllopod Crustacea from the Gallowhill Limestone include, besides the two species *Dithyrocaris tricornis* and *D. testudinea*, others whose specific characteristics have not yet been determined. Their mode of occurrence and state of preservation are strongly suggestive of the conditions under which these fossils appear in the Calderwood Cementstone. No traces of the Schizopods which occur in the Calderwood Cementstone have as yet been found in the Gallowhill Limestone, but further search may yet reveal the presence of some of these most interesting forms.

The Brachiopod fauna of the Gallowhill Limestone is strikingly similar to that of the Calderwood Cementstone. In the Carluke district the Calderwood Cementstone is known as the Lingula Limestone, because of the large numbers of that fossil which occur in it. In the Gallowhill Limestone *Lingula squamiformis* is replaced by *Lingula mytiloides*, which, as has already been pointed out, occurs in great numbers. The more common Brachiopods in the Gallowhill Limestone are *Productus longispinus*, *P. semireticulatus*, and *Rhynchonella pleurodon*, and less commonly *Discina nitida* and *Streptorhynchus crenistria*.

Lamellibranchs are exceedingly scarce in the upper part or estuarine phase of the Gallowhill Limestone, but several specimens referable

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to *Sanguinolites plicatus* have been found, and one specimen closely resembling *Protoschizodus æquilateralis* and *Posidonomya corrugata* also occurs, and from the lower and more crinoidal parts *Nuculana attenuata* and *Nucula gibbosa* have been obtained.

The Cephalopoda are represented in the upper or estuarine part of the limestone by *Orthoceras attenuatum* and by a *Nautilus* which has not been specifically determined.

Fish remains, in the shape of scales, spines, and plates, occur in the upper part of the limestone, though in a somewhat fragmentary condition. They are clearly referable to those ganoids which are found in the estuarine facies of the Carboniferous formation.

Plant remains are fairly common, principally the fronds of ferns, and occurring as they do in association with the Phyllopods and with *Productus longispinus* and other Brachiopods they tend to accentuate the resemblance between the Gallowhill Limestone and the Calderwood Cementstone.

From what has been said it will be seen that the whole assemblage of plants and animals found in the Gallowhill Limestone is strikingly similar to that which occurs in the Calderwood Cementstone. That these strata are of estuarine origin is made clear by the manner in which the remains of land plants and animals are intermingled with those of estuarine and marine types, just as we find in estuarine deposits at the present day.

I have to acknowledge my indebtedness for much assistance in working out the details of the Gallowhill district to Mr. William Holmes, of Sandyford.

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REVIEWS.

I.—THE ORIGIN OF THE EARTH. By T. C. CHAMBERLIN. 8vo; pp. xi, 271. University of Chicago Press. 1916.

THIS book might appropriately have as a sub-title "The Intellectual Autobiography of a Geological Cosmographer and his Reflections on the Genesis and Geographical Evolution of the Earth". The author has collected into a small monograph the results of his studies of the origin of the earth, and the further development of