

the side of the old Wealden Hill-range or mountain, which once rose about 3000 feet above where Crowborough and other hills in Sussex now are. Man existed at the time of these gravels, and used the flints for tools. These gravels and the implements left in them were removed by natural agencies, such as rain, rivers, sea, frost, and ice, and distributed by torrential streams on the Chalk slopes (now part of the North Downs) at a lower level on the flanks of the range.

These rude old flint implements have an ochreous colouring, due to ferruginous gravel, whence they came; and are now found on the plateau, sometimes with limited patches of some of the ochreous flint gravel, together with Tertiary pebbles, less-worn flints, and fragments of Lower Greensand, on the red "clay-with-flints" covering the Chalk. It is shown how desirable systematic excavations, to prove the extent and thickness of the implementiferous soil, would be.

Prof. Prestwich's history of the origin of the ancient Wealden Dome, Island, and Hill-ranges, and of the gradual destruction of those uplands, in the course of untold ages, with the resulting formation and removal of successive geological groups of strata, such as the Thanet Sands, Woolwich and Reading Beds, London Clay, Lenham Beds, and the old ferruginous gravel with its rude implements above mentioned, are noticed in detail.

The Diestian or Lenham Beds were found in the Early Pliocene period; and the denudation of Holmesdale probably began directly afterwards, at about the time of the Red or the Chillesford Crag in Late Pliocene, or in post-Pliocene times; and the old ferruginous gravel had not only been formed, but washed away to a lower level before that time.

The ultimate denudation of the valley cutting off the Chalk from the Weald being subsequent to the formation and removal of that gravel, the latter must have been pre-Glacial in age.

REVIEWS.

I.—(1) LES PREUVES DE L'EXISTENCE D'ORGANISMES DANS LE TERRAIN PRÉ-CAMBRIEN, PREMIÈRE NOTE SUR LES RADIOLAIRES PRÉ-CAMBRIENS. Par M. L. CAYEUX. Bulletin de la Société Géologique de France, 3^e s., tome xxii. pp. 197–228, pl. xi., année 1894.

(2) SUR LA PRÉSENCE DE RESTES DE FORAMINIFÈRES DANS LES TERRAINS PRÉ-CAMBRIENS DE BRETAGNE. Note de M. L. CAYEUX, présentée par M. FOUQUÉ. Comptes Rendus de l'Académie des Sciences. Tome cxviii. No. 25 (18 Juin, 1894), pp. 1433–1435.

- (1) Proofs of the existence of Radiolarians in Pre-Cambrian rocks. By M. L. Cayeux.
(2) Remains of Foraminifera in the Pre-Cambrian of Brittany. By M. L. Cayeux.

ABOUT two years since Dr. Charles Barrois announced, in a brief note to the "Comptes Rendus," the discovery of Radiolaria in Pre-Cambrian rocks of the horizon of the mineral schists and phyllites of St. Lô, in the north of Brittany. The further description

of these, probably the oldest fossils known, was intrusted to M. L. Cayeux, who has had considerable experience in the study of Radiolaria and other microscopic organisms in the Cretaceous rocks; and the first of the above papers contains the results of a careful investigation into the nature of these bodies from an examination of numerous sections of the rocks in which they are preserved.

From the geological sections of the country drawn up by Dr. Barrois no doubt can be felt as to the horizon of the fossiliferous beds, which are bands of phtanite from half-an-inch to over three feet in thickness, interstratified with the schists. The phtanites are now principally of crystalline silica, and a certain amount of carbonaceous material is also present in them.

The bodies described as Radiolaria are irregularly distributed in the phtanites, sometimes occurring singly, at others great numbers are closely associated together, so as occasionally to be in actual contact. They are exceedingly small in size—the figured forms range from .001 mm. to .022 mm. in diameter—and to observe their structures it is needful to use much higher object-glasses than those required for other fossil and recent Radiolaria. By far the larger number are simply spherical in form, some are ellipsoidal, and there are many varieties of the inflated or cyrtoidal bell-shaped forms. One or more radial spines occur in several forms, and in two or three an inner concentric shell connected by rays with the outer test has been detected. Most of the forms figured have holes or perforations in the outer test, thus showing a lattice-like structure. This is considered by the author to be present in all, though not always recognisable.

The author has figured 45 different forms of these minute bodies, and the greater number are assigned to different known Radiolarian genera, 19 in all; a few forms cannot be placed in any described genus, but all are comprised in four of the great subordinal divisions of Haeckel, viz., Sphæroidea, Prunoidea, Discoidea, and Cyrtosidea. The author thus confidently asserts the close relationship of these Pre-Cambrian forms to existing and other fossil Radiolaria.

It will readily be conceded that, at a first glance, the forms which the author has had figured on the accompanying plate by an artist unacquainted with these organisms (and therefore unbiassed) present a strong *prima facie* resemblance to known Radiolaria. Certain objections have, however, been made to placing them in this group by some who have had the opportunity of seeing sections of the rock containing them, and the author has very fairly and candidly stated these objections and replied to them in the paper. It should, perhaps, be mentioned that the figures now given have been taken from specimens lately obtained by the author, which show their characters more distinctly than in those which came under the notice of the objectors.

One objection is based on the extremely small size of the Pre-Cambrian bodies as compared with the dimensions of undoubted Radiolaria. This difference is very striking under the microscope, and it may be expressed by the fact that the average diameter of the

44 figured forms of which the dimensions are given is $\cdot 0115$ mm; whilst the average diameter of 44 of the Palæozoic Radiolaria figured by Dr. Rüst (taking the 44 species first described) is $\cdot 2$ mm.; thus it would require the combined diameters of 17 of the Pre-Cambrian bodies to reach the average diameter of one of the Palæozoic Radiolaria. The author considers that the small dimensions of the ancient forms may possibly arise from different biological conditions, and, that as size does not enter into the diagnosis of recent Radiolaria, the objection is not valid in the present case. It may, however, be noted that there is no important difference in the size of existing Radiolaria and that of fossil forms as far down as the Silurian and Ordovician rocks, and there is, therefore, no ground for anticipating that still earlier forms would be more diminutive than those of Ordovician and later times. Other objections are based on the fact that it is only in some of these bodies that perforations can be discovered, whilst it is also stated that they are too regularly spherical to be Radiolaria, and further that the bodies are not organic but are produced by the juxtaposition of small rounded granules, and that the interstices between these give the appearance of perforations. The author considers that such an interpretation is inconsistent with the law of optics, and that the perforations are really pores in the siliceous test.

Dr. Rüst, judging from the section supplied to him by the author, considered that the small rounded bodies more nearly resembled the detached chambers of Foraminifera than Radiolaria, thus allowing the organic character of the forms present; but this view does not account for the larger perforations in the test of some, and further will not apply to those which are bell-shaped. The author has, however, since the publication of the first paper, communicated a note to the "Comptes Rendus," in which he asserts the Foraminiferal character of some of the bodies in the Pre-Cambrian phanites associated together with the forms described as Radiolaria. Of these Foraminifera, both simple and compound forms are present, but the simple specimens are hardly to be distinguished from those Radiolaria in which the pores are obliterated. The compound forms consist of a variable number—ranging from 2 to 7—of spherical or ovoid chambers of different sizes aggregated together. In some cases the chambers are furnished with one or more short blunted spines. The walls are very finely perforate, and they are therefore included in the perforate group of Carpenter. In size they correspond with the Radiolarian bodies; the largest of the chambers hardly reaching the diameter of 10 micromillimetres ($= \cdot 01$ mm. or about $\frac{1}{2500}$ of an inch), and thus the objection made to the Radiolarian bodies on account of the disparity in size in comparison with recent forms will equally apply to these Foraminifera.

The importance of determining the real character of the minute bodies in these Pre-Cambrian rocks will be generally recognised, and we cordially trust the author will persevere in his researches until he meets with evidence sufficient to convince those who now feel some hesitation in accepting his conclusions about them.

G. J. H.