

though these may well be nothing more than the 'doggers,' or 'potlids,' so characteristic of calcareous sandstones. Mr. Winwood believes that "the so-called foreign boulder" in the Gloucester Museum evidently came from the 'Harford Sands.'

So far, therefore, the evidences of glacial action in the Cotteswolds do not rest on a very sure foundation. Yet the Severn Valley separates that range from an area on the west, where there are clear evidences of local glaciation, as described in the Annual Report of the Geological Survey for 1896. Portions of this material find their way into the river bed and elsewhere as Drift which has most probably been rearranged; hence the so-called Boulder-clay and Drift in the bed of the Severn. Once more, then, in the cycle of geological time we perceive that our district lies on the confines of two distinct sets of phenomena. West of the Severn and north of the Bristol Channel the evidences of considerable local glaciation are obvious, whilst this can hardly be said of the Cotteswolds, the Mendips, or the Quantocks.

To the more recent geological history of our district it will be sufficient to allude in the briefest terms, when I remind you of the paper by Mr. Strahan on the deposits at Barry Dock, and the still later one by Mr. Codrington on the submerged rock valleys in South Wales, Devon, and Cornwall. Here we have important testimony to certain moderate changes of level which have taken place, and a picture is presented to us of the Bristol Channel as a low-lying land-surface, with streams meandering through it. Thus a depression of something like 60 feet appears to be the most recent change which the geologist has to record in the estuary of the Severn.

## REVIEWS.

I.—CONTRIBUTION À L'ÉTUDE MICROGRAPHIQUE DES TERRAINS SÉDIMENTAIRES. I. Étude de quelques dépôts siliceux secondaires et tertiaires du Bassin de Paris et de la Belgique. II. Craie du Bassin de Paris. Par LUCIEN CAYEUX, D. ès Sc. 4to; pp. 589, pls. x, and 20 figures in the text. (Lille: Le Bigot Frères, 1897.)

IN this elaborate work Dr. Cayeux gives the results of an extended series of investigations into the minute structure of the sedimentary rocks mainly of the Paris Basin, but including as well some in the North of France and adjoining areas in Belgium. The age of the rocks treated of ranges from the Jurassic to the Eocene, but the greater number belong to the Cretaceous Series, from the Albian to the Senonian, or, in English terms, from the Gault to the Upper Chalk with *Belemnites mucronata*. The author's aim has been, by a close study of the present characters of the deposits, to ascertain their natural history, and to trace the effects of the various mechanical, chemical, and physiological agencies to which they

have been subjected, and thus to gain an idea of their original structure and of the conditions under which they were formed. The work has been carried on by means of microscopic sections, chemical analyses, and more particularly by the study of the residues after treatment of the calcareous rocks with acid.

The first part of the volume contains a description of the siliceous deposits known in France and Belgium under the names of 'Gaize,' 'Meule,' 'Smectique,' 'Têtes de Chat,' 'Rabots,' and 'Tuffeau.' Other synonyms of the Gaize are 'Grès Vert,' 'Craie tufan,' 'Pierre morte,' and 'Pouzzolane.' Typical Gaize is a soft, porous, dirty gray or yellow siliceous rock of a sandy texture, with a varying amount of soluble silica in its composition. It frequently contains harder compact nodules, comparable in some respects to chalk flints, but unlike them in not being sharply delimited from the softer matrix. It is as a rule rich in the débris of siliceous organisms, with variable amounts of quartz (sand-grains) and glauconite, also in some instances a small proportion of carbonate of lime. These constituents are usually cemented together by opalized or by chalcedonic silica. It may be said in passing that the 'Gaize' corresponds with those siliceous beds in the Lower and Upper Greensand of this country generally referred to as 'Chert,' 'Malm,' 'Sponge-rock,' etc.

Deposits of Gaize are prominently developed on three distinct horizons in France: (1) in the Oxfordian beds of the Middle Jurassic Series in the Ardennes; (2) in the Albian (= Lower Gault), also in the Ardennes; and (3) in the Cenomanian (= Upper Greensand) in Argonne and Pays de Bray.

The Jurassic Gaize, in the zone of *Amm. (Cardioceras) Lamberti* and *Amm. Mariei*, is only known in the Ardennes, where it attains a thickness of about 50 metres. The soluble silica varies in different specimens from 9 to 56 per cent., and glauconite forms one-tenth of the rock. The organic constituents are principally minute rounded, oval or kidney-shaped, siliceous bodies, which are sufficiently numerous to constitute one-third to one-half of the rock, and with these are fractured siliceous sponge spicules. In some examples both the matrix and the rounded bodies are replaced by calcite. The author recognizes the similarity of these rounded and reniform bodies to those first described by Dr. Sorby from the corresponding horizon in the Calcareous Grit of Yorkshire, but he does not consider them to belong to *Geodia* sponges, owing to the absence of the corresponding skeletal spicules, and to the hollow condition in which many of these bodies now occur. It has, however, been shown that definite sponges occur in the Yorkshire beds apparently wholly made up of these peculiar rounded bodies (Quart. Journ. Geol. Soc., vol. xlvii, 1890, p. 54), a fact which Dr. Cayeux seems to have overlooked.

The Gaize of the Albian zones of *Amm. mammillaris* and *Amm. interruptus* is partly a soft porous rock, partly a coarse glauconitic grit; one sample yielded 28 per cent. of soluble silica. Spicules of

Monactinellid, Tetractinellid, and Lithistid sponges abound in the beds; they are now mainly of opal, but some are of chalcedonic silica. Not infrequently the spicules have been dissolved, and their empty casts remain in a cement or groundmass of amorphous silica.

The Gaize of Argonne in the Cenomanian zone of *Amm. inflatus* has a thickness of 80 to 105 metres. The amount of soluble silica ranges from 5 to 56 per cent. Sponge-remains in some beds constitute half the rock; they are of opal, chalcedony, pyrites, glauconite, or merely hollow casts. There are also a few Radiolaria, some doubtful diatoms, and, where lime is present, a few Foraminifera, belonging to *Textularia*, *Globigerina*, etc. The cement is mostly of colloid silica, frequently in the condition of minute globules, like those in the sponge-rock of the Upper Greensand of this country.

The Gaize of the zone of *Amm. Mantelli* in the Department of Cher, is very similar to that of Argonne. The soluble silica in it varies from 15 to 35 per cent.; the sponge-remains constitute from one-tenth to one-eighth of the rock, and there are likewise a few Radiolaria. The cement of this Gaize is also largely of globular colloid silica.

In the Gaizes above mentioned sponge spicules form the essential element. They vary considerably in numbers in different beds: in some they are estimated to form one-half, in others not more than one-tenth of the rock. Radiolaria and diatoms are present, but in very insignificant proportions, and occasionally a few Foraminifera. In the softer and friable kinds of Gaize the silica of the cement or groundmass is colloid in character, but in the harder kinds it is in the form of chalcedony. The author does not consider that the silica of the cement in the Gaize is entirely due to sponge remains, but that a certain proportion of it is derived from the decomposition of the argillaceous constituents of the rock; the evidence for this, however, is not by any means convincing.

The Meule de Bracquignies, near Mons, belonging to the zone of *Amm. inflatus*, is practically of the same character as the Gaize of Argonne. The soluble silica ranges up to 25 per cent.; some beds are nearly wholly composed of sponge débris, in others this forms about one-half the rock.

In the vicinity of Liège and in the district of Herve (Belgium) the rock known as Smectique, belonging to the zone of *B. quadrata* (= Upper Chalk), consists of marls and glauconitic sands from 20 to 30 m. in thickness. It contains 15 per cent. of soluble silica. The rock is rich in sponge remains, now converted into chalcedony; it has also some well-preserved Radiolaria, a few diatoms, and a considerable number of Foraminifera. Unlike typical Gaize, the cement in this rock is mainly calcareous.

The deposits of 'Tuffeau' of Eocene age which occur in the North of France and in Belgium are very similar in character to the Gaize and Meule. They may be described as greenish or greyish glauconitic sands with argillaceous and calcareous materials, and a cement of soluble silica. Some beds are hard and tenacious, others

friable. Sponge spicules, and in some instances diatoms, appear to have furnished the soluble silica, which varies in amount from 11 to 27 per cent.

A chapter is devoted to the study of the glauconite so common in the Gaize and Tuffeau. The author brings forward evidence to show that a considerable proportion of this material has been formed long after the deposition of the beds in which it now occurs, and consequently that its origin is entirely independent of organic matter.

Chapter VI contains a description of the Radiolaria occurring in the Smectique de Herve. Though limited in numbers, there is a great variety of forms present, which are placed under twenty-seven genera. The predominant forms belong to the Discoidea, and mainly to the family Porodiscida; the Cyrtodea are also well represented. Two or three new genera are proposed: one of these, *Monostylus*, appears to be a synonym of *Dorysphaera*, Hinde (Ann. and Mag. Nat. Hist., ser. vi, vol. vi, 1890, p. 52). The rock containing these Radiolaria is regarded as a terrigenous rather than a pelagic deposit, since sand grains are present in it; the organisms are, however, altogether too few to give the rock any pretension to be radiolarian in character.

The second part of the volume contains a detailed description of the composition of the Turonian and Senonian Chalk of the Paris Basin. The different areas treated of are: the North, Pays de Bray, Rouen and district, South-East, South-West, West, and North-West of the Basin. The Turonian Chalk is subdivided into the zones of *Actinocamax plenus*, *Inoceramus labiatus*, *Terebratulina gracilis*, and *Micraster breviporus*, and the Senonian into those of *Micraster cor-testudinarium*, *M. cor-anguinum*, and the Chalk with Belemnites. The composition of the Chalk of the respective zones in each area is given, showing the various kinds of organic remains, the nature of the minerals in the residues, whether formed in the rock or of clastic derivation, and also the nature of the cement.

Excepting in the Turonian beds of the Nord and Pays de Bray, the proportion of mineral residues in the Chalk of the Paris Basin—leaving the argillaceous material on one side—is less than 1 per cent. Quartz or sand grains are the most important constituents. The grains range on an average between 0.04 mm. and 0.12 mm. in diameter, but in all the deposits there are some reaching to 0.2–0.4 mm. They are mainly angular, with blunted edges; some are rounded, and a few crystals have been formed *in situ*. Many other kinds of mineral grains are associated with the quartz, such as zircon, tourmaline, rutile, magnetite, apatite, chlorite, etc.

Quartzite pebbles (galets) and fragments of schist occur not infrequently in the Senonian beds in the vicinity of Lille. Most of them are between 2 and 8 grams in weight; the largest noticed weighed 300 grams (= 10 oz. av.). They resemble some of the primary rocks of the Ardennes.

The principal secondary minerals formed in the Paris Chalk, in addition to flints, are glauconite, phosphate of lime, calcite, pyrite,

limonite, manganese, quartz, opal, etc. Glauconite occurs throughout, both as casts of organisms and as independent grains. The phosphate of lime is either amorphous or crystalline; some of the grains are free from all connection with organisms and formed in place. The nodules of this material have a strong preservative influence on the organisms, whether calcareous or siliceous, which they inclose. They are more numerous in beds which indicate some disturbance or interruption of the normal conditions of deposition.

The calcite in the Chalk occurs in isolated rhombohedral crystals, which are very generally distributed; these are oftentimes dissolved, leaving perfect geometrical cavities. This dissolution frequently takes place in an apparently capricious manner; certain bands of Chalk retaining the crystals, whilst in alternating bands they are completely removed. The rock with the hollow casts is usually soft and friable, that with the crystals hard and durable; and in beds where the calcite crystals have been partially dissolved, the portions intact appear as nodular masses inclosed in a soft matrix.

With respect to the flints, the author considers that they may have been formed at several periods in the history of the Chalk in which they now occur, and, further, that in the Paris Basin the amount of silica they represent bears a close relation to the number and volume of the sponge spicules in the same beds which have been replaced by calcite. The rarity or absence of flints in the Chalk cannot be taken as a reliable index of the part played by sponges in the particular beds, for the silica of the sponge remains may be dispersed through the Chalk in the form of minute colloidal globules, instead of being aggregated into flints, or it may have been carried by solution into lower beds.

Of the organic remains in the Paris Chalk, the débris of Molluscan and Brachiopod shells occurs throughout; more particularly is this the case with the detached prisms of the shells of *Inoceramus*, which in certain beds near Lille, at the top of the Turonian and at the base of the Senonian, are sufficiently numerous to form nine-tenths of the Chalk.

Polyzoa are very largely developed in some of the Turonian Chalks of the South-West of the Basin, where even the finer particles of the beds are mainly composed of their comminuted remains. Echinoderm fragments are present at all horizons, but they are less abundant in the Turonian than in the lower part of the Senonian. Corals play an uncertain part, possibly on account of their aragonitic character.

Though detached sponge spicules occur throughout the Chalk of the Paris Basin, it is necessary to dissolve a considerable amount of the Chalk to obtain them in the residues. Occasionally large numbers are present: for instance, in some beds at Meudon they are estimated to form one-fifth of the rock, and in the *M. cor-anguinum* zone at Maintenon, one-fourth. The most constant horizon for sponge-remains in the Paris Basin is at the summit of the Turonian. The *I. labiatus* and *T. gracilis* beds of the South-West and West of the Basin are distinguished by the abundance of Lithistid

spicules and the scarcity of Hexactinellid forms; whilst, on the other hand, the zone of *M. breviporus* is characterized by Monactinellid and Tetractinellid spicules. In the Senonian, Hexactinellid spicules appear in the residues. Detached spicules of Calcsponges are found in all the Chalk beds.

The remains of siliceous sponges are now only exceptionally preserved in colloid silica; most commonly they are replaced by calcite or by glauconite, and more rarely by pyrites, phosphate of lime, or by limonite. The author notes the rarity of empty casts of spicules in the Chalk as compared with those in the Gaize, but this may be less than appears, since the empty casts are very inconspicuous in the Chalk, and careful observation with a lens is needed to distinguish them.

The author also calls attention to the fact that Lithistid spicules are not replaced by glauconite the same as spicules of other groups of sponges in the Chalk. The explanation of this appears to be that the replacement of siliceous spicules by glauconite is effected by way of infilling of their axial canals; and as in the skeletal spicules of Lithistids the axial canals are, as a rule, very slightly, if at all, developed, replacement by glauconite does not occur. The spicules (so termed) in nearly all the groups from the Chalk figured by the author are, in fact, merely the solid infilling by glauconite of the enlarged axial canals of genuine spicules: this is shown by the even thickness and the truncation of the ends of the spicular rays. The contrast between these glauconitic replacements and actual spicules may be seen in the figures of a group of the latter (fig. 13, p. 290) from the upper zone of the Turonian Chalk of Rouen.

A few Radiolaria have been observed at different horizons in the Chalk; they are more numerous in the Senonian. In some instances they retain their siliceous structure; in others this has been replaced by calcite or phosphate of lime.

The proportion of Foraminifera in the Chalk examined varied from 5 to 80 per cent.; the maximum amount was found in the Turonian Chalk of the Rouen district. Forms of *Globigerina* are stated to play a subordinate rôle as compared with those of *Textularia* and *Rotalia*. The thickness of the foraminiferal tests varies considerably in different beds, and probably indicates variations of depth in the seas of the period.

Diatoms have been but rarely observed; on the other hand, Coccoliths and Rhabdoliths are present everywhere, the former by far the most numerous. The author regards them as pelagic Algæ.

The cement or matrix of the Paris Chalk is composed of fine particles derived from the breaking up of the various organisms, the microscopic Algæ, and crystals of calcite; it varies in amount from one-tenth to nine-tenths in different beds and localities. In every sample of chalk examined the organisms present show traces of dissolution, and there is no evidence of any direct chemical deposition of carbonate of lime from the sea-water.

The author unhesitatingly considers the typical Chalk of the Paris Basin, such as that of the Pays de Bray, the Rouen district, and the

East and South-East areas, as pelagic sediments. This typical Chalk consists of 90–98 per cent. of carbonate of lime; the proportion of silica is, in general, insignificant, save in the *I. labiatus* zone, which shows an analysis of 14 per cent.; the argillaceous materials do not, as a rule, exceed 1 per cent. The Senonian chalks, which are now poor in micro-organisms, were probably originally foraminiferal in character. The changes which have taken place in the original sediments tend to produce a crystalline calcite in which all traces of organization have disappeared.

In the two concluding chapters of the work a comparison of the Chalk with the recent *Globigerina* ooze is made, and the conditions of the Cretaceous sea considered. The author's opinion that the depth of this sea at the time of the greatest depression, when the *Belemnitella* chalk was forming, did not exceed 150 fathoms, certainly does not err on the side of excess.

The work is illustrated by some excellent phototypes of sections of different kinds of Gaize and beautifully executed lithographic plates of Radiolaria, enlarged sections of Chalk, glauconite, and other minerals.

G. J. HINDE.

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II.—THE GEOLOGY OF THE COUNTRY AROUND BOURNEMOUTH. By CLEMENT REID, F.L.S., F.G.S. *Memoirs of the Geological Survey*. 8vo; pp. iv, 12, with 14 illustrations. (London, 1898. Price 4d.)

IN our July number we noticed the recently published *Geology of Bognor* issued by the Geological Survey; we have now to announce a companion memoir on Bournemouth, in explanation of the New Series Map Sheet 329. The Director-General, in his preface, briefly refers to previous geological works, while the author gives a concise account of the geological features. Reference is especially made to the labours of Mr. J. Starkie Gardner, who has done more than any other geologist to make known the life-history of the Eocene strata on the Hampshire coast. Figures are given of a number of the characteristic Barton fossils, and it is interesting to observe that most of the species were illustrated more than 130 years ago by Brander. The strata noted are the Upper Chalk, the entire Eocene series, the Headon Beds, and various Pleistocene and Recent deposits.

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## CORRESPONDENCE.

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### THE SUBMERGED PLATFORM OF WESTERN EUROPE.

SIR,—Mr. Jukes-Browne's letter in the September number of the *GEOLOGICAL MAGAZINE* must not be left without some reply, notwithstanding that I have since dealt with its subject in some detail at the Bristol meeting of the British Association. The facts and