NOTICES OF MEMOIRS.

I.—The Action of Waves and Tides on the Movement of Material on the Sea-coast. By W. H. Wheeler, M.Inst.C.E., Boston, Lincolnshire.[1]

THE object of this paper is to show the relative effect of waves due to wind and tidal action on littoral drift. It is pointed out that all cliffs that border the sea-coast are doomed to erosion, and the material derived from their destruction, after being sorted and prepared by waves and tidal action, is conveyed to the depths of the sea. The function of wind waves is to break down the cliffs, to sort the material displaced, and to reduce the larger rock fragments into sizes sufficiently small to be acted on by the tides, and to disperse material that has been collected in large masses by tidal action. The function of the tides consists in raising the water of the ocean sufficiently high to enable the waves to attack the cliffs, in assisting in the grinding up of the reduced rock fragments by their perpetual oscillating motion until sufficiently reduced in size, and then in transporting them to the bed of the sea, the latter operation being effected either in solution, suspension, or rolling along the bottom.

It is shown that all material eroded from the cliffs is ultimately carried seaward, and that the sea yields nothing to the land. The only agents capable of transporting material of greater specific gravity than the water are the waves, and their action, until they break on the shore, is merely one of undulation; and therefore it is only the stones, shingle, or sand which lie shorewards of the point where the wave breaks that can be carried forward on to the beach. On the other hand, the slope of the beach being seawards, all material has a natural tendency to work downwards under the action of gravity, this downward action being aided by the undertow of the retiring shore waves.

Material eroded from the cliffs consists of rock fragments, boulders, sand, and alluvium. The alluvium, consisting of particles of sufficient minuteness to remain in suspension for a considerable time, is diffused by the waves over a very considerable distance, and is finally deposited in the deep part of the ocean; the sand is gradually worked down the beach by the action of the waves and tides, and is also spread over the sea bed, but nearer to the shore; the rock fragments are reduced to shingle small enough to be acted on by the tides, and in this condition are rolled up and down the beach and drifted along the coast until ground into particles sufficiently fine to be transported to the sea. Shingle is generally accumulated in banks in the zone lying between low-water of neap tides and high-water of spring tides, and travels along the coast in one given direction. The heaping up and travel of the shingle is due to tidal action. The effect of wind waves due to gales is principally destructive to shingle banks, cutting out and dispersing the material, the banks being restored by tidal action in calm weather and during offshore winds. The action of waves due to wind is intermittent, variable in direction, and irregular. The travel of shingle, except when acted

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on by gales, is continuous, regular, and constant in direction. It is shown by a number of examples that the travel of shingle is not coincident either with the prevailing or predominant winds, but on a tidal coast the predominant drift is invariably in the same direction as that of the flood tide. The action of the tides in heaping up and drifting material is due to wave action. The rise and fall of the tide on the coast does not consist of a mere vertical rise and fall of the water, but of a continual oscillation. The crest of the tidal wave in the open sea, being in advance of that near the shore, results in an oblique lateral movement along the beach, and the advance of the water being checked by the shallow bed with which it comes in contact, is reflected back, resulting in a series of small oscillations or waves which break when they reach the low-water line. These oscillations are ever present on the margin of the shore, even when the sea is calmest, and are never absent except when absorbed by larger waves due to gales. These tidal wavelets vary in height from 6 inches to 2 feet, and break on the shore at the rate of from ten to twenty a minute according to the rise of the tide and the slope of the beach. These wavelets, aided by the flood current, lift up and carry forward any coarse sand, loose stones, or other material with which they come in contact, and leave some portion of it stranded at the highest point to which the tide of the day reaches. The wavelets, besides lifting and transporting the shingle, brush upward the whole of the face of the bank, and gradually raise it above the line of high-water. It is shown that, though these waves are small, they by their weight and velocity develop sufficient force to move a large quantity of pebbles. A wave having a height of only a foot from trough to crest, giving a head of 6 inches, and containing a volume of water equal to a weight of ·142 ton has sufficient kinetic energy to raise 165 lbs. of pebbles a foot high. Allowing the weight of pebbles in water to be 100 lbs. to the cubic foot, each wave, if the whole of its energy be applied to the movement of the material, is capable of raising 660 pebbles 2 inches in diameter a foot; or, with fifteen waves to the minute, 9,900 pebbles a minute and 2,376,000 in a single tide, or a total weight of stone of 266·4 tons a foot high. This, however, is beyond the work actually done, as a portion of the energy of the wave is absorbed in friction. The above rough approximation of the power of the wavelets is sufficient to show the enormous power that is developed by tidal action day by day on the coast, and the capability of the wavelets due to the tides for building up shingle banks and drifting the pebbles along the beach.

II.—Leadhillite in Ancient Lead Slags from the Mendip Hills.[1] By L. J. Spencer, M.A., F.G.S., British Museum (Natural History).

LEAD ores have been worked in the Mendip Hills (East Somerset) ever since the time of the Romans; but during the present century operations have been chiefly confined to the reworking of the

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old waste heaps of slags and slimes. From these heaps upwards of 9,000 tons of lead was extracted during the ten years ending 1880. The material now being worked at Priddy has the appearance of a brown earth: it contains fragments of charcoal and limestone, and about 6 per cent. of lead as carbonate. Embedded here and there in this material are blocks consisting of devitrified slag, partially fused galena, and fragments of charcoal; and in the cavities numerous small crystals of cerussite ($Pb\,C\,O_3$) and anglesite ($Pb\,S\,O_4$) and, less frequently, of leadhillite.

Leadhillite has not been before observed under such conditions. In the Roman lead slags at Laurion in Greece, which have been in contact with sea-water, Lacroix has noted the following secondary minerals: matlockite, penfieldite, laurionite, fiedlerite, phosgenite, cerussite, hydrocerussite, and anglesite.

The colourless crystals of Mendip leadhillite have, perpendicular to the perfect basal cleavage, an acute negative bisectrix with an optic axial angle in air of $2E = 72\frac{3}{4}°$; at a temperature of 97° C., $2E = 70\frac{1}{2}°$. The frequent twinning and the goniometric measurements (which are, however, not very good) are not inconsistent with the orthorhombic symmetry insisted upon by Miller. The basal planes of complicated twin crystals always give a single sharp reflected image, which is not the case with twin crystals of ordinary monosymmetric leadhillite. A few crystals are optically uniaxial.

There therefore seem to be three kinds of leadhillite, all of which are identical in outward appearance: (*a*) Monosymmetric, with the optic axial angle $2E = 20°$; (*b*) rhombohedral (?) and optically uniaxial (susannite); (*c*) orthorhombic, with $2E = 72\frac{3}{4}°$.

Before 1874 the formula for leadhillite was given as $PbSO_4.3PbCO_3$, and that now usually accepted is $PbSO_4.2PbCO_3.Pb(OH)_2$; but no two of the several analyses that have been made are in close agreement, and other formulæ have been proposed. Doubtless each of the above kinds has a definite chemical composition, and the variations shown by the different analyses are possibly due to the fact that two—(*a*) and (*b*) or (*b*) and (*c*)—of the three kinds may occur together in the same crystal, as observed by Bertrand and by myself in specimens from Leadhills. It will therefore be necessary to examine optically each fragment that is collected for future analyses of leadhillite.

III.—Gigantic Irish Deer-Remains.—Report of the Committee, consisting of Professor W. Boyd Dawkins (Chairman), His Honour Deemster Gill, the Rev. E. B. Savage, Mr. G. W. Lamplugh, and Mr. P. M. C. Kermode (Secretary), appointed to examine the Conditions under which remains of the Gigantic Irish Deer are found in the Isle of Man.[1]

We were able to add a footnote to our report of last year to the effect that a fairly perfect skeleton of *Cervus giganteus* had been discovered, of which we hoped to hand in details with this year's report. These remains were found in a marl-pit at Close-y-

[1] Communicated to the British Association, Bristol, September, 1898, Section C (Geology).

Garey, on the east side of the railway line, half a mile north from St. John's, and the same distance south from Poortown station.

The bones were nearly all in juxtaposition and, excepting the ribs and pelvic bones and one shoulder-blade, in a very fair state of preservation. The antlers were nearly complete; the beams, however, are represented by fragments, the skull also is fragmentary.

The left antler is the larger; it measures across the palm 15 inches, allowing for a piece of the front edge which has decayed away; the right measures 13 inches. With the tines, most of which dropped off on lifting from the marl, they are respectively 56½ inches and 53 inches long, and the beam would have been about 10 inches more. They show six points, besides the brow-tines, which had fallen off, the portion of the beam to which they were attached having decayed away.

The palm of the left antler lay over the lumbar vertebræ, and the right over the fore-quarters. The upper jaw teeth were preserved on both sides, and those of the left lower jaw were embedded in the ramus. A fragment of the right symphysis was also present, and there were various fragments of a skull which had been broken up before the discovery.

One of the ribs had been perforated, probably by the point of an antler of another elk in one of their usual fights. It was fractured as well as perforated, and had been healed. This injury, therefore, was not connected with the death of the animal, which took place in its full prime, as shown by the perfection of the teeth and the dimensions of the antlers.

Professor Boyd Dawkins examined the bones in December and made the measurements of the skeleton found at Close-y-Garey.

Excavation No. 1 in disturbed soil yielded fragments of upper jaw (teeth worn) of *Cervus giganteus.*

The skeleton lay in white marl at a depth of about 9 feet from the present surface, on its right side, the legs drawn up to the body, the head towards the margin of the ancient pool, now a morass, which lies in a hollow in the glacial drifts.

From the position of the bones the animal appeared to have died where it was found, not to have been washed down by floods. About sixty years ago the bog had been worked for marl, and the present well-defined banks mark out a rectangular hollow some 50 yards square and about 3 feet below the surrounding surface.

Across one corner of this a trench was dug to carry off the water, and the operations of the Committee were confined to a triangular area on the west side of the trench, measuring about 15 yards east and west, by about 30 yards north and south. They excavated all over this space to a depth of over 9 feet. The first four excavations, being through ground which had previously been disturbed, yielded no definite results, but at one point a few bones were met with, among which were fragments of maxilla, the sixth cervical vertebra, the second lumbar vertebra, and a fragment of a rib. In association with these were remains of horse represented by a radius and lower jaws of two individuals. Though the ground

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had been disturbed the horse bones probably belonged to the same age as the Great Deer. A fragment of a metatarsal, met with in digging the trench, had an artificial perforation.

The result of all the excavations, allowing for the disturbed state of the ground, showed the following beds :—

		Ft.	in.
A.	Disturbed soil and peat, an average of about	3	0
B.	*In one place a blue clay or silt was observed resting on the white marl.*		
C.	White marl containing the remains of the Gigantic Deer	6	6
D.	Blue marl[1]	1	0
E.	Red sand with gravel	0	3
F.	Brown clay	0	3
G.	Sand and gravel } ? Glacial drift {	0	3
H.	Clay ... ... } ? Glacial drift {	4	0

As stated above, the whole surface had been lowered about 3 feet in digging for marl; the peat had for the most part been removed, and a great deal of the marl also; indeed, we were fortunate in finding this one spot in which the marl itself had not been disturbed.

The finding of detached bones shows that other individuals had perished here, and is consistent with what we were told, that a specimen had been seen when digging for marl, and that the antlers of another had been taken out. We were told also that two skulls without antlers had been seen on the other side of our trench.

Samples of the marl and other beds were forwarded to Mr. James Bennie, of Edinburgh, who again most kindly undertook the laborious task of washing and sifting the material. The organic remains thus obtained were examined by Mr. Clement Reid, who has determined the following plants :—

From Peat B.

Ranunculus flammula, L.
Viola palustris, L.
Rubus fruticosus, L. (very small).
Potentilla tormentilla, Neck.
,, *comarum*, Nestl.
Carduus crispus, L.
Menyanthes trifoliata, L.
Empetrum nigrum, L.
Potamogeton, sp.
Carex, 4 sp.

Also beetles, 3 sp., and caddis cases.

From Marl C.

Ranunculus repens, L.
Viola palustris, L.
Potentilla comarum, Nestl.
Myriophyllum spicatum, L.
Rumex obtusifolius, L.
Empetrum nigrum, L.
Potamogeton, sp.
Carex, 4 sp.
Chara, sp.
Umbelliferous plant (unripe).

From Red Sand D.

Plant-remains, not determined.

From Bed E.

Betula alba.
Potamogeton, sp.
Carex, sp.
Bracts of sedge.
Leaves (?).

Mr. R. Okell examined the White Marl for Diatoms, but found no trace. There are no fresh-water shells in it.

[1] This was noticed below the skeleton, and may have been discoloured by the decay of the body.

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In our last report we were able to announce the discovery in a previous excavation near Ballough of the Arctic crustacean *Lepidurus glacialis*, and accompanied by the Arctic willow *Salix herbacea* in a bed of silt occurring above *Chara*-marl, like that of the present section. In that locality, however, we did not succeed in finding elk-remains in the marl, probably on account of the limited character of our excavation, as we have every reason to believe that the skeleton now in Edinburgh Museum was obtained from that bed. In the present instance, though we have found the elk, it will be noticed that the section contains no trace of the Arctic fauna. This is greatly to be regretted, since—as was pointed out by Mr. C. Reid in our last report—the relation of this fauna to the bed containing the elk is a point of great theoretical importance. It is also important that the presence of the horse in the wild fauna of the Isle of Man should be placed beyond doubt by working in undisturbed ground. The same group of animals may be expected as that which occurs in the prehistoric strata of Ireland and England. Under these circumstances we propose to apply for a further grant to carry on explorations which will probably definitely settle these interesting questions.

The balance of the grant, renewed last year, was expended in the preliminary work of draining; further funds, which enabled the Committee to continue the work and to exhume the specimen which has now been set up in Castle Rushen, Isle of Man, were provided by the local Society, which also contributed the amount required for mounting the skeleton.

The best thanks of the Committee are due to Messrs. C. Reid, J. Bennie, and R. Okell for the valuable assistance they have rendered in the investigation.

IV.—Supplementary List of British Minerals.[1] By L. J. Spencer, M.A., F.G.S., British Museum (Natural History).

During the forty years which have elapsed since the publication of Greg and Lettsom's "Manual of the Mineralogy of Great Britain and Ireland," a considerable number of species, variety and other names have been added to the list of minerals occurring in the British Isles. In 1858 Greg and Lettsom recognized 241 British species, but of these only 209 are given as numbered species by Dana in the sixth edition (1892) of his "System of Mineralogy." To this list may now be added 84 more, bringing the total number of British species up to 293, as compared with the total of 824 known mineral species recognized by Dana in 1892. Owing to the difficulty in some cases of defining a mineral species, to the uncertainty of some of the determinations, and to the fact that a systematic search through the whole of the literature has not yet been made, these numbers can only be considered approximate.

Some of the most notable additions are of minerals which have been detected by the microscopical examination of rock-sections,

[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

e.g., nephelite, nosean, and various felspars, pyroxenes, and amphiboles.

In the following list are added 113 other names which have been applied to British minerals; the species are distinguished by italics. The first observer and date have been added (in parenthesis) wherever possible; in other cases the earliest reference found is given.

Abriachanite (Heddle, 1879).
Achroite (Collins, 1876).
Ægirite (Teall, 1888).
Aikinite (Museum Pract. Geol.).
Albertite (Morrison, 1884).
Alunogen (Smithe, 1882).
Amazon stone (Heddle, 1877).
Amblystegite (Judd, 1885).
Andesine (Heddle, 1877).
Andrewsite (Maskelyne, 1871).
Anorthite (Haughton, 1856).
Antigorite (Heddle, 1878).
Antimony ? (Garby, 1848).
Atacamite (Church, 1865).
Balvraidite (Heddle, 1880).
Baricalcite (Breithaupt, 1841).
Barytocelestite (Collie, 1878).
Bastite.
Bathvillite (Williams, 1863).
Bauxite (Sutherland, 1870).
Bayldonite (Church, 1865).
Beekite.
Beraunite (Greg, 1860).
Bhreckite (Heddle, 1879).
Botallackite (Church, 1865).
Bowlingite (Hannay, 1877).
Braunite ? (Collins, 1871).
Bruiachite (Macadam, 1886).
Bytownite (Teall, 1884).
Cantonite (Davies, 1877).
Cathkinite (Glen & Young, 1882).
Celadonite (Heddle, 1879).
Centrallassite (How, 1878).
Chalcosiderite (Maskelyne, 1875).
Chenevixite (Adam, 1866).
Chloritoid (Heddle, 1879).
Chloropal (Church, 1866).
Chlorophyllite (Heddle, 1882).
Chrome-diopside (Teall, 1888).
Chrysoberyl (Haughton, 1856).
Chrysotile.
Churchite (Church, 1865).
Cleavelandite (Heddle, 1877).
Clinochlore (British Museum).
Cloustonite (Heddle, 1880).
Coccolite (Heddle, 1877).
Collyrite (Gladstone, 1862).
Cotterite (Harkness, 1878).
Craigtonite (Heddle, 1882).
Crocidolite (Heddle, 1879).
Cryptolite (Church, 1872).
Danalite (Miers & Prior, 1892).
Daphnite (Tschermak, 1891).
Delessite (Heddle, 1879).
Demidoffite (Greg, 1860).
Descloizite (Frenzel, 1875).
Devilline (Pisani, 1864).
Dolianite (Des Cloizeaux, 1862).
Dudgeonite (Heddle, 1889).
Dufrenite (Kinch & Butler, 1886).
Duporthite (Collins, 1877).
Edenite (Heddle, 1878).
Electrum (Forbes, 1867).
Ellonite (Heddle, 1882).
Enstatite.
Enysite (Collins, 1876).
Eosite (Schrauf, 1871).
Eulytite (Collins, 1881).
Evansite (Woodward, 1884).
Ferrite (Heddle, 1882).
Fibrolite (Heddle, 1882).
Fichtelite (Macadam, 1889).
Frieslebenite ? (Museum Pract. Geol.).
Funkite (Heddle, 1882).
Genthite (Heddle, 1878).
Gersdorffite (Forbes, 1868).
Gigantolite (Heddle, 1882).
Glaucophane (Blake, 1888).
Gramenite (Collins, 1877).
Grastite (Heddle, 1878).
Grossular (Heddle, 1878).
Grünlingite (Muthmann & Schröder, '97).
Halloysite (Heddle, 1882).
Haughtonite (Heddle, 1879).
Hausmannite (Goodchild, 1875).
Henwoodite (Collins, 1876).
Hibbertite (Heddle, 1878).
Hisingerite (Church, 1870).
Hovite (Gladstone, 1862).
Hullite (Hardman, 1878).
Hydrated labradorite (Heddle, 1880).
Hydrocerussite (Heddle, 1889).
Hydrophilite (Spiller, 1876).
Hydroplumbite (Heddle, 1889).
Hydrozincite (Goodchild, 1883).
Iddingsite ? (Arnold-Bemrose, 1894).
Igelströmite (Heddle, 1878).
Inverarite (Heddle, 1883).
Jarrowite (Lebour, 1887).
Johannite ? (Garby, 1848).
Langite (Maskelyne, 1864).
Latrobite (Heddle, 1877).
Lepidomelane (Haughton, 1859).
Lettsomite (British Museum).
Leuchtenbergite (Glen & Young, 1876).
Leucoxene (Geikie, 1879).

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Limnite (Church, 1865).
Linnæite (Terrill & Des Cloizeaux, 1880).
Liskeardite (Maskelyne, 1878).
Loganite (Harkness, 1866).
Löllingite (Collins, 1871).
Ludlamite (Field, 1877).
Lussatite (Mallard, 1890).
Lyellite (Maskelyne, 1864).
Marmolite (Heddle, 1878).
Martite (Heddle, 1882).
Massicot ? (Collins, 1871).
Melanite (Teall, 1892).
Microcline.
Mirabilite (Glen & Young, 1876).
Monazite (Miers, 1885).
Montmorillonite (Collins, 1878).
Mottramite (Roscoe, 1876).
Mountain silk, etc. (Heddle, 1879).
Necronite (Heddle, 1877).
Neotype (Breithaupt, 1841).
Nephelite (Allport, 1871).
Nephrite (Heddle, 1878).
Nosean (Allport, 1874).
Okenite (Glen & Young, 1876).
Oligoclase (Haughton, 1862).
Omphacite (Teall, 1891).
Orangite (Heddle, 1883).
Ottrelite (Hutchings, 1889).
Pargasite (Heddle, 1878).
Penninite (Heddle, 1878).
Penwithite (Collins, 1878).
Perthite (Heddle, 1883).
Phlogopite ? (Heddle, 1878).
Pickeringite (British Museum).
Picotite (Bonney, 1877).
Picrolite (Heddle, 1878).
Piedmontite (Dana, 1892).
Pihlite (Heddle, 1879).
Pilolite (Heddle, 1879).
Plumboaragonite (Collie, 1889).
Plumbogummite (Dana, 1850).
Plumbonacrite (Heddle, 1889).
Polybasite (Joy, 1860).
Polytelite (Forbes, 1867).
Prasilite (Thomson, 1840).
Protolithionite (Sandberger, 1885).
Proustite (British Museum).
Pseudo-hypersthene, etc. (Heddle, 1878).
Pseudophite (Heddle, 1879).
Pyroaurite (Heddle, 1878).
Pyrophyllite (Foster, 1876).
Pyrosclerite (Heddle, 1879).
Reichite (Breithaupt, 1865).
Restormelite (Church, 1870).
Rhabdophane (Lettsom, 1878).
Riebeckite (Harker, 1888).
Rock silk, etc. (Heddle, 1879).
Rubislite (Heddle, 1879).
Sanidine.
Scapolite (Ormerod, 1869).
Schraufite ? (Thomson, 1887).
Schrötterite (Dana, 1868).
Senarmontite (Davies, 1867).
Sericite.
Spangolite (Miers, 1893).
Spessartite (Heddle, 1878).
Stephanite (Davies, 1866).
Tallingite (Church, 1865).
Tavistockite (Church, 1865).
Thorite (Heddle, 1883).
Tobermorite (Heddle, 1880).
Totaigite (Heddle, 1878).
Tridymite (Lasaulx, 1876).
Turgite (Heddle, 1882).
Tyreeite (Heddle, 1881).
Uigite (Heddle, 1856).
Uralite.
Valentinite (Hall, 1868).
Vauquelinite (Davies, 1877).
Vermiculite (Parke, 1877).
Voltzite (Dana, 1868).
Walkerite (Heddle, 1880).
Waringtonite (Maskelyne, 1864).
Wicklowite (D'Achiardi, 1883).
Willemite (Glen & Young, 1876).
Wittichenite ? (Collins, 1871).
Woodwardite (Church, 1866).
Xantholite (Heddle, 1879).
Xanthosiderite (Haughton, 1866).
Xonotlite (Heddle, 1882).
Zeunerite (Weisbach, 1872).

V.—On Arborescent Carboniferous Limestone from near Bristol.[1] By Horace B. Woodward, F.R.S.

A SPECIMEN of Carboniferous Limestone showing arborescent markings was obtained by Mr. Spencer G. Perceval from Brentry Hill, near Henbury, Bristol, and was presented by him in 1897 to the Museum of Practical Geology. The rock is about six inches thick, and the lower half is a current-bedded oolitic limestone. The upper half comprises banded calcareous mud with a few layers of oolitic grains, and the material in this portion of the rock has been disturbed, the layers having been bent; while the hollows

[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

between the curves are partially eroded and filled with irregular detrital material containing oolitic grains.

The surface of the block presents an irregular concretionary structure, resembling that seen on many varieties of Cotham Marble; but it is not so pronounced as in some of the mammillated surfaces seen in that rock.

The appearances are probably due to mechanical disarrangement of the upper layers produced prior to and during the consolidation of the rock, and they suggest a pause in the deposition of sediment.

It is noteworthy that the darker bands which produce the arborescent markings stand out slightly in relief on the weathered face of the block of Carboniferous Limestone. This is also the case with an example of Cotham Marble which I lately obtained on the South Wales Direct Railway at Stoke Gifford.

A small specimen of Carboniferous Limestone from Backwell, near Nailsea, given to me by Mr. W. H. Wickes, shows indications of arborescent markings. [Further references to the subject are given in the GEOL. MAG., Dec. III, Vol. IX, 1892, p. 110, and in "The Jurassic Rocks of Britain," Mem. Geol. Surv., vol. v, p. 230; see also B. Thompson, Quart. Journ. Geol. Soc., vol. L (1894), p. 393.]

VI.—THE BUILDING OF CLIFTON ROCKS. By E. WETHERED, F.G.S.[1]

IN this paper the author confines his remarks chiefly to the microscopic life which he has discovered in the Carboniferous Limestone rocks at Clifton. He contends that microscopic calcareous organisms have been the chief contributors to the vast deposits in the Carboniferous sea, now represented by the cliffs on either side of the gorge of the Avon at Clifton.

Broadly speaking, there were three stages in the formation of this limestone. These were regulated by physical conditions, and favoured the existence of certain forms of life. The fossil remains now denote the stages. They are as follows:—

	Approximate Thickness.
Stage 1. Lower Limestones (including the Lower Limestone shales, 500 feet, and Black Rock series, 470 feet)	990 feet.
Stage 2. Middle Limestone	1,620 ,,
Stage 3. Upper Limestone	100 ,,

The close of the Old Red Sandstone period is marked by variegated sandstones and shales. These beds pass into limestones and shales, and these again are followed by massive limestones locally known as the Black Rock; the whole representing the Lower Limestones, or Stage 1.

During this stage encrinites were so numerous in the waters that the ossicles of these creatures are a distinguishing feature of the limestones. Vast numbers of ostracoda at times lived, and some beds of the limestone are chiefly accumulations of the remains of these small crustaceans. Monticulipora corals and polyzoa were numerous in the waters, and also mollusca.

[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

Another interesting feature, not before noticed in the Lower Limestones, is the mass of incrusting organisms. These organisms formed a crust around the fragmental remains of other bodies which collected on the sea-floor, and to such an extent did this process go on that the incrusting organisms contribute considerably to the building up of some beds of limestone. Whether these crusts are to be attributed to animal or vegetable growth is a matter of doubt.

The crinoidal life reached a climax during the time that the Black Rock Limestone was in process of formation. Indeed, this rock is, in the main, a vast accumulation of the ossicles of these "stone-lilies," associated with shells of mollusca, fish remains, etc.

The Black Rock series terminate in dolomitized limestone, and on this rest the 'Gully Oolites.'

The Lower Limestones terminate at these oolites, in which occur, though sparingly, foraminifera and the minute spherical object *Calcisphæra*. This latter body averages about ·012 of an inch in diameter, but, small as it is, the calcareous sphere has been an important contributor to the building of the rocks.

As *Calcisphæra* is confined to the Carboniferous Limestone, and is so numerous that it is seldom a thin section of the rock is obtained without finding it, the organism is useful in determining the strata when doubtful. So far, the author has not found *Calcisphæra* in the Lower Limestones, and the same remark applies to foraminifera.

Above the horizon of the Gully Oolite the lower beds of the Middle Limestone are characterized by the occurrence of the curious organism *Mitcheldeania*, but it is not confined to this horizon.

Next follow limestones and calcareous shales full of the remains of little understood forms of microscopic life, which must have existed in great profusion.

As before remarked, the Middle Limestones are characterized by foraminifera and *Calcisphæra*. At first these occur sparingly, but later on the rock is little more than a Carboniferous foraminiferal ooze. Remains of corals occur and other well-known fossils, but the bulk of the 1,600 feet of limestone included in the Middle Series is in the main a vast calcareous deposit of the remains of microscopic life which lived in the Carboniferous waters.

Owing to the Upper Limestones being so built over, the author is at present not in a position to describe the microscopic life which the strata probably contain associated with larger organisms.

VII.—On the Probable Source of the Upper Felsitic Lava of Snowdon.[1] By J. R. Dakyns, M.A.

BETWEEN Glaslyn and Bwlch Goch, as the lowest part of the ridge between Crib Goch and the top of Crib y Ddysgl is called, a mass of felstone rises like a wall through the beds of the calcareous ashy series. The trend of the dyke is E.N.E. The best section is along the N.W. face, where the felstone is clearly seen standing as a wall against the truncated edges of the calcareous

[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.

ashy beds. The felstone shows ***lines of flow parallel to its side***, and in some places is rudely columnar, ***the axes of the prisms being perpendicular to the side of the dyke.*** It is owing to this arrangement of the columns, and of the lines of flow, that I consider the rock to be a dyke. I call it a dyke because of the straightness of its sides; but it is rather a boss than a dyke, as, while it is two hundred yards wide, it is only about three or four hundred yards long. The rock is not like any of the lower Snowdonian felsites occurring in the immediate neighbourhood, but it is decidedly like the upper felstone, which forms outliers on Crib Goch and Crib y Ddysgl. It seems to me that we have here the source of the upper felsitic lava of the Snowdon district. The boss is a plug of rock consolidated in and filling up the orifice through which the upper lava flowed to the surface.

VIII.—On Worked Flints from Glacial Deposits of Cheshire and the Isle of Man.[1] By J. Lomas, A.R.C.S., F.G.S., Pres. Liverpool Geol. Soc.

FLINTS are not common in the glacial deposits of N.W. England. In one or two places in the Wirral, however, and in the Isle of Man, they are fairly plentiful. Sometimes they occur in the Boulder-clay, but more frequently in Glacial Sands and Gravels. Some of the flints collected in these localities show undoubted signs of human workmanship.

Prenton, Birkenhead.—The flints exhibited were collected from a recent excavation near Mount House. Soft Bunter is seen on the south and west faces overlain by glacial sands. Between the two lies a bed of gravel containing small Lake District and Scotch erratics up to six inches in diameter, along with broken Triassic rocks, clay galls, and marine shells. In this gravel most of the flints have been found. Others occur in the overlying sand, which also contains erratics and shell fragments. Similar sand occurs at many places in the immediate neighbourhood, and is usually overlain by Boulder-clay.

Spital Sandpit. — False-bedded clean sand is seen, containing gravel and rolled clay galls, overlain by tough Boulder-clay. The flints occur both in the gravel and Boulder-clay.

Capenhurst.—Flints collected from gravel bands and clay in old sandpit opposite church.

Mollington, near Chester.—The large sandpit, near high road, contains very little gravel, and the flints mostly occur in the Boulder-clay which caps the section.

Cliffs north of Ramsey, Isle of Man.—Glacial deposits in north of island well exposed in the fine cliffs which extend from Ramsey almost to the Point of Ayre. Near Ramsey, sands and gravels predominate, and these get successively more and more clayey towards the north.

In collecting the flints I took great care to separate those found in the talus slopes from those actually in the clays and gravels. The flints are exhibited and speak for themselves.

[1] Read before Sect. C (Geology), British Association, Bristol Meeting, Sept. 1898.