the sea over the previous site of the Fluvio-marine Crag, as well as over the Red Crag, the latter was also taken up and re-deposited. This accounts for the extreme comminution of the shells in the lower parts of the sections above mentioned, and also for the strong evidences of false current bedding. Only the stronger shells, such as *Pectunculus glycimeris, Fusus contrarius*, etc., could survive this wear and tear, and these are the common Red Crag shells met with. At the same time they are associated with undoubtedly Norwich Crag forms, such as *Mya truncata, M. arenaria, Tellina obliqua, T. pretenuis, Buccinum undatum, Purpura lapillus, Littorina littorea*, etc. These lived in the sea where the Red Crag was being re-deposited, and their remains thus became admixed with those of a former period. Many of the shells last mentioned are more or less fragile, and show that they could not have been subjected to the same violence as their previously deposited associates. Of course the greatest amount of re-deposition would be seen in the lower beds, and the least in the upper, which is exactly the case inall these sections.

In conclusion, it seems to me clear that the old "Mammaliferous," or Norwich Fluvio-marine Crag, was a north-easterly extension of the Red Crag. When the depression of the area took place, there was formed along it the Upper Norwich or "Chillesford" Crag. Between this and the Fluvio-marine beds, strata of sand were thrown down and intercalated. But in Suffolk, where the Red Crag reached such an enormous thickness, its upper portions were taken up and re-deposited in false current bedded layers, where the stronger fossils became mixed with the shells of the later period. Hence in such areas this comminuted Red Crag, whose Norwich Crag forms have given such trouble, is really the work of the sea where the Chillesford beds were accumulated. At Sudbourne Church walks we find this Upper Crag reposing on the Coralline Crag, and the same phenomenon is visible in the railway cuttings near Aldborough Station, where it rests in a denuded hollow of Coralline Crag. I submit these views to Crag geologists, with the hope that they may assist in interpreting a perplexing phenomenon. If they are correct, then we have, in the Eastern Counties, a perfectly marked and unbroken sequence from the Coralline Crag up to the latest Drift deposit.

NOTICES OF MEMOIRS.

I.—On the Flotation of Sand by the Rising Tide in a Tidal Estuary.

By Professor Hennessy, F.R.S., Vice-President of the Academy.

(Read before the Royal Irish Academy, April 10, 1871.)

During the course of a tour along our western coast, in the summer of 1868, the following incident came under my notice; and, although I made a note of the facts at the time, I have never hitherto made them the subject of a scientific communication :—

On July 26, when approaching the strand at the river below the village of Newport, County Mayo, I noticed what appeared to be extensive streaks of scum floating on the surface of the water. As it was my intention to bathe, I was somewhat dissatisfied with the appearance of the water, until I stood on the edge of the strand, and I then perceived that what was apparently scum, seen from a distance, consisted of innumerable particles of sand, flat flakes of broken shells, and the other small débris which formed the surface of the gently-sloping shore of the river. The sand varied from the smallest size visible to the eye up to little pebbles, nearly as broad and a little thicker than a fourpenny piece. Hundreds of such little pebbles were afloat around me, and it is probable that the flakes of floating matter seen farther off contained also a considerable proportion. The air during the whole morning was perfectly calm, and the sky cloudless, so that, although it was only half-past nine, the sun had been shining brightly for some hours on the exposed beach. The upper surface of each of the little pebbles was perfectly dry, and the groups which they formed were slightly depressed in curved hollows of the liquid.

The tide was rapidly rising, and, owing to the narrowness of the channel at the point where I made my observations, the sheets of floating sand were swiftly drifting farther up the river into brackish and fresh water. On closely watching the rising tide at the edge of the strand, I noticed that the particles of sand, shells, and small flat pebbles, which had become perfectly dry and sensibly warm under the rays of the sun, were gently uplifted by the calm, steadily-rising water, and then floated as readily as chips or straws. I collected a few specimens of these little objects, but I regret that they have been since mislaid. This phenomenon, it is scarcely necessary to say, is due to molecular action, such as accompanies the familiar experiment of floating needles on the surface of a basin of water. Although the specific gravity of the floating objects exceeds that of the fluid on which they rest, the principle of Archimedes still holds good, because the displacement of liquid produced by the body is considerably greater than the volume of the body itself. In the case of a floating needle, the repulsion of the liquid from the polished surface of the metal presents a groove, whose magnitude is obviously many times greater than the needle; but in the case of the floating pebbles this was not so manifest. The specific gravity of needles made of fine hard steel may be taken at 7·9 nearly, while that of the little pebbles scarcely exceeds 2·6, so that other things being equal, the latter would require one-third of the displacement required by the former for perfect flotation. But, moreover, the small pebbles which I saw floating were always flat and thin, and rested with their broadest surface on the water. The attraction of the molecules of water for one another produces, as is well established, a tension at the surface of the liquid, which, although extremely feeble, and generally noticed only in connexion with capillary phenomena, yet interposes some resistance to the intrusion of foreign substances. This is seen in the experiment of floating broad spangles or sheets of dry gold-leaf on a

vessel of water. When a piece of gold-leaf is held edgeways it sinks, and it also sinks if wetted. In fluids more viscid than water, such as lava or melted metals, flat pieces of the stone or solid metal are known to swim on their broad surfaces, while they sink when turned on their edges. I have recently made a few experiments on the flotation in water of small bodies of greater density than the liquid, and I find that needles have remained for days together floating. I have also easily floated sand, flat pieces of shells, and small pebbles for several days, and whenever they sank, it was due to some disturbance of the liquid sufficient to produce a wave on its surface. Mr. Alphonse Gages placed twenty-four needles on the surface of a large basin of water, and after a few hours they were found grouped in parallel parcels, varying in their contents from two to seven needles. They continued to float for more than five days, and their sinking was evidently due to the progress of oxidation, which destroyed their polish, together with their repulsive action on the liquid. I have floated small flat pebbles, similar in size and appearance to the largest of those observed floating on Newport river, for more than six days, while fragments of shells, and thin pieces of slate as broad as a sixpenny piece, have continued to float much longer. These little bodies occasionally sank from the gradual absorption of water, but much more frequently from some accidental motion of the vessel containing the liquid.

It is manifest that the flotation of sand in a tidal estuary, as in the instance I have seen, can occur only under favourable conditions. The shores must be very gently inclined, the air perfectly calm, and the weather dry and warm. Under these circumstances thin cakes or sheets of sand may not only be uplifted by the water, but if the tide flows rapidly they may continue afloat sufficiently long to allow many of them to be drifted far from their original place up to the higher limit of the brackish water. In this way fragments of marine shells and exuviæ might become mingled with those belonging to fresh water. The conditions favourable for sand flotation must exist during calm weather in a very high degree of perfection on the sandy shores of tidal rivers in tropical and subtropical districts of the earth. As this phenomenon can take place only with the rising tide, and never with the falling tide, the result must generally be favourable to the transport of sand and marine débris in the direction of the flow of flood tide; and this may sometimes hold good along a coast as well as on the shores of a tidal estuary. Geologists, as far as I am aware, have not hitherto noticed this phenomenon in connexion with the formation of stratified deposits by the agency of tides and rivers, although they have paid great attention to the influence of the molecular resistance of water to the sinking of very minute solid substances, with the view of explaining the wide surface over which matter held in suspension by water may be spread when ultimately deposited over the sea-bottom.[1]

[1] Since this paper was written, I have been informed by a lady, that she observed similar phenomena during a former summer, close to the sandy seashore at Youghal; and Dr. E. Percival Wright has stated that he has witnessed the realization of the results which are alluded to as likely to occur within the tropics.

II.—Geological Survey of Ireland.

1. Explanatory Memoir to accompany Sheets 104 and 113, with the adjoining portions of Sheets 103 and 122 (Kilkieran and Aran Sheets). By G. H. Kinahan, M.R.I.A., H. Leonard, M.R.I.A., and R. J. Cruise, M.R.I.A. 8vo. Dublin, 1871. pp. 92.
2. Explanatory Memoir to accompany Sheets 86, 87, 88, and Eastern part of 85. By G. H. Kinahan, M.R.I.A., and R. G. Symes, F.G.S.; with Palæontological Notes by W. H. Baily, F.L.S., F.G.S. 8vo. Dublin, 1871. pp. 63.

THE first Memoir is taken up with a description of the Aran Islands, and portions of the mainland of Galway contained in the maps enumerated. The mainland, which possesses no town, is intersected by numerous chains of lakes, bays, and creeks. The land is low, averaging from 200 to 500 feet in elevation. From the north-east shores of the Aran Islands the land rises in a series of cliffs or huge steps, which form continuous terraces; while from the summit of Inishmore, one of the islands, there is a gradual fall south-westward, ending at the sea-board, in cliffs now being formed by the Atlantic Ocean.

The formations met with include:—Bog and Alluvium, Glacial Deposits, Carboniferous Limestone, Granitic and Igneous Rocks. The Granites are of two classes, the intrusive, and those of apparently metamorphic origin.

The lithological character of these rocks is treated of at length; the authors then pass on to the relations between the form of the ground and its internal structure. The Aran Islands are composed of limestones, with thin shales and clay interstratified, and to the effects of denudation on them is due the terraced-form they now possess. In the metamorphic rock country are peaks and knolls composed of hornblende rock. The action of ice is very conspicuous in this district; a table of supposed ice striæ is given.

For convenience of description the area is divided into five sub-districts, and these are described in detail.

Of the drifts, there is a local boulder or moraine drift, consisting of a sandy or clayey mass, full of small and large fragments of local rock, often several tons in weight.

The Bogs are of two kinds, the low-lying, flat, or peat bogs, which are often of considerable depth, and the mountain bogs that frequently grow on steep slopes.

Some of the low bogs are most deceptive, being seemingly a solid surface, but having water or mud underneath; and, as they are clothed with vegetation in the spring, they are very dangerous to cattle. At this season, when grass is scarce, the cattle, and especially horses, are tempted to venture on them, when they go down bodily, and often only the heads of the horses remain uncovered. The authors think in this way to account for the skeletons of the *Megaceros Hibernicus* being so frequently found in small isolated bogs,

and also for the fact of their skulls being found separate from the remainder of the skeleton.

There are some Notes on Mines and Mineral Localities, in which are noticed the spots where mining operations have taken place, and also the localities where lead, copper, and sulphur have been found.

2.—The second Memoir is occupied in the description of parts of the counties of Galway, Mayo, Roscommon, and Longford, situated between the towns of Ballinrobe and Longford. The country is gently undulating, with a good deal of bog on the east and west, and for the most part with bare crags in the centre. The outline of the eastern shore of Lough Mask (a part only of which is contained in the maps now described) presents a remarkable contrast to that of its western shore. For while the latter maintains a nearly even line, the eastern shore is indented by numerous bays and inlets, ranging in a N.N.E. direction, and running far into the heart of the limestone country, where they spread out into wide but shallow loughs. The general direction of these arms is shown to be parallel to the glacial striations of the district.

The formations represented are Alluvium, Peat Bog, etc.; Drift Gravel, Clay, and Boulders; Carboniferous Limestone, and Yellowish Grits and Conglomerates; Lower Silurian Rocks; and Felstone.

The Lower Silurian rocks, which consist of grits and slates, have yielded no fossils, but in all probability they are on the same geological horizon with the Silurian rocks of Cavan, Monaghan, and Armagh. The Yellowish Grits and Conglomerates rest on the denuded edges of the Lower Silurian beds, and in places they are seen to pass up into the Carboniferous Limestone. They are regarded by Mr. Symes as of Carboniferous age, an opinion in which Professor Hull concurs. Mr. Baily furnishes a list of fossils from the Carboniferous rocks of the area.

Separating the area into districts, the authors give a detailed description of each.

Three-fourths of it is covered with a thick mantle of Drift, which is divisible into Boulder-clay and Eskers. The Boulder-clay is for the most part of local origin.

The tortuous ridges of gravel called Eskers are composed of sand, gravel, and large boulders, running generally in a north-east and south-west direction. Tables of supposed ice striæ are given.

III.—Proceedings of the Bristol Naturalists' Society. Vol. 5. 1870.

PROMINENCE has been given to Geology in the papers read before the Bristol Naturalists' Society during the year 1870, and which are published in this the fifth volume of their Proceedings. These papers include the following:—

1. Temperature and Life in the Deep Sea, being some Account of the Deep-Sea Dredging Expedition in H.M.S. *Porcupine*, in the Summer of 1869. By W. L. Carpenter, B.Sc., B.A.

2. On some Evidence in favour of Subsidence in the South-west Counties of England during the Recent Period. By E. S. Claypole, B.Sc., B.A.—Referring to the peat-beds that exist in many places on our south-western coast, and particularly to those around Cornwall, Mr. Claypole pointed out their general arrangement as exemplified at Gyllyngvaes, Falmouth. Here the peat-bed overlies a very tenacious clay, and is covered by the ordinary shingle of the coast to such an extent that only at very low water is it exposed to view. Speaking of the plant remains of these peat-beds, he sees no ground for assuming that any of them belong to species even locally extinct. Their present position seems to him to indicate a subsidence of at least 42 feet, for they could hardly have been formed at a lower level than 20 feet above high-water mark. He considers the raised beaches to be of earlier date than the peat-beds, and that there is no evidence of upheaval since the growth of this vegetation.

3. The Quaternary Deposits of the Bristol Neighbourhood. By W. W. Stoddart, F.G.S., F.C.S.—The area to which Mr. Stoddart's remarks apply extends from Portishead and Falfield on the north, to Glastonbury and Bruton on the south. Its physical geography during the Quaternary period is shown on a small map accompanying the paper. During the Glacial period Mr. Stoddart thinks that the waters of what is now the Bristol Channel most likely reached the foot of the Mendip and Cotteswold Hills, and washed the sides of the innumerable islands that appeared above the waves, such as Glastonbury Tor, Dundry, Ashton, Clifton, etc., which then were completely isolated from the mainland. He then points out some of the subsequent changes, and the animals which flourished at the time, and are now found fossil in the caves. These caverns or fissures are considered by Mr. Stoddart as owing their origin to convulsions, when a "great volcanic outburst" formed the magnificent gorges of Clifton and Cheddar!

4. On the Igneous Rocks of Shropshire. By W. W. Stoddart, F.G.S., etc.

5. On Denudation. By C. F. Ravis.—The author pointed out some of the general effects of denudation in Somersetshire.

6. On the Structure of Rubies, Sapphires, Diamonds, and some other Minerals. By H. C. Sorby, F.R.S., and P. J. Butler. (From the Proceedings of the Royal Society, 1869.)

7. Notes on the Geology of Weymouth. By W. W. Stoddart, F.G.S., etc.

8. On Fossil Fish. By W. Sanders, F.R.S., F.G.S.—This was a continuation of the subject; the author described the characters of the Ganoid division of Fishes.