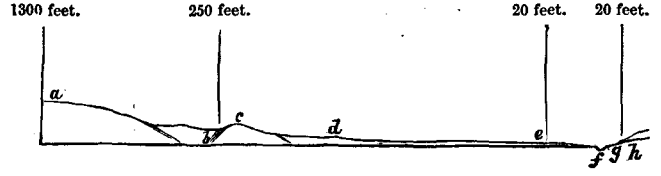
interval of time consumed is so immense, that our insect eyes are often as incapable of discerning, as our minds of grasping, the facts which she lays before us. It is only by a long and close process of reasoning that we can arrive at the solution of a single problem.

SECTION OF THE TERN VALLEY SHOWING THE RELATIVE POSITIONS OF THE DRIFT-BEDS.



(*a*) Summit of the Wrekin.
(*b*) High level drifts, on Red Sandstone.
(*c*) Protrusion of Basaltic rock.
(*d*) Sand.
(*e*) Clay under peat, lake basin.
(*f*) Present river-level.
(*g*) Low-level drift.
(*h*) Bank of river valley.

The accompanying diagram shows the relative positions of the Drift-beds I have described. Although not, perhaps, strictly correct, it is so nearly so as to afford a sufficient guide to any geologist desirous to examine these beds.

NOTICES OF MEMOIRS.

GEOLOGICAL PAPERS READ BEFORE THE BRITISH ASSOCIATION, AT DUNDEE.

I.—NOTICE OF AN "ESKAR" AT ST. FORT, FIFESHIRE. By Dr. ROBERT CHAMBERS, F.R.S.E., F.G.S.

ESKARS, though of frequent occurrence in Ireland, and very numerous in Sweden, where they are recognised by the plural word "ösar," are comparatively rare in Scotland. One of a very striking character occurs about three miles inland from Newport, on the road from Dundee to Cupar-Fife, and on the estate of Mr. Stewart, of St. Fort. It is fully a mile long, and in some parts half a mile broad; rises from thirty to forty feet above the neighbouring ground, and is, unfortunately for the geologist, wholly covered with trees. Its surface is rough and uneven. Several good sections, produced by the cuttings for the road to Kilmany, show it to be composed of gravel chiefly rounded, including many large pieces, some of which are of Primitive rocks. The skirts of this "eskar" melt into a vast gravelly tract of cultivated ground, undulating towards Balmerino, but in other directions forming flat surfaces on a higher level. Elsewhere there are gravel mounts of less elevation, with rounded tops. The whole are manifestly relics of a vast sheet of alluvium at between eighty or ninety feet above the present level of the sea, extending southward into the valley of the Eden, and thence eastward by Kincaple and Strathtyrum to St. Andrews. The history of this great sheet of alluvium is probably connected with

Glacial action in the Tay, in the upper part of which, about Weem, there are decided moraines. In most of the great outlets from the Alpine regions of Scotland—as, for example, the valleys of the Spey, the Findhorn, and the Ness—there are smaller sheets of gravelly alluvium gathered about the places where the valleys open into the low country. In the case of the alluvial sheet here described, there has been sufficient denudation and outsweeping to account for the sand-banks which so largely encumber the mouth of the Tay, and give so much trouble to the mariners of Dundee.

II.—On the Old Sea Cliffs and Submarine Banks of the Firth of Forth. By D. Milne Home, F.R.S.E., F.G.S.

IN describing the line of old sea-cliff along both sides of the Firth of Forth, which had been formed before the last change in the relative levels of sea and land, Mr. Home stated that its height at the lower parts of the estuary was about thirteen or fourteen feet above the present level of the sea, whilst near Stirling it was about thirty-one feet, and to the west about thirty-five or forty feet. He also specified two higher and older cliffs at heights of about sixty feet and one hundred and thirty feet respectively. Skeletons of whales and seals had been found at heights varying from eighteen to twenty-three feet above the present level of high-water-mark, and sea shells were found in two conditions—viz., first, in undisturbed beds, now fourteen and fifteen feet above high-water-mark, entire and perfect; and, secondly, in beaches, where they were broken. He explained the origin of the Estuary of the Firth, by the great east and west fractures in the country adjoining, to the north and south. He said that in the Fife Coal-field, the downcasts were almost all on the south side of the fractures, and amounted altogether to nearly 2,000 feet; and in the Coal-field of the Lothians, Linlithgow, and Stirlingshire, the downcasts were, on the other hand, to the north, and even to a greater extent, thus producing a trough or hollow, now filled by an arm of the sea. The rocks in this hollow were covered by various drift deposits, the oldest being Boulder-clay, and, over it, stratified clay, sand, or gravel. The gravel was generally on the top, which was accounted for by the water of the Estuary shallowing, whereby the currents became more powerful, and thus gravel was laid down where only mud or sand could be laid down before. Mr. M. Home next proceeded to describe a long ridge of gravel running four or five miles through Callendar Park, by Polmont eastward towards Linlithgow. He stated that its height was from thirty to sixty feet, and, judging from the materials composing it, he considered it had been formed by sea-currents. He said that these gravel ridges were very numerous in our open valleys, and that their direction or course was invariably parallel with the axis or sides of the valley. Though he had not seen the ridge of gravel at St. Fort, described in Dr. Chambers's paper, he could not help thinking it was to be accounted for in the same way, viz., by marine

currents, and not as an effect of ice action. He exhibited some Admiralty charts, showing the submarine banks and spits existing in the English Channel, all of which were in like manner parallel to the sea-coast. If this bank was formed in that way, the sea must have stood at least 350 feet higher than now, and, in that view, an explanation was afforded of several phenomena in the district, such as the smoothed appearance of the hard whinstone rocks of Stirling, Craigforth, Airthrey, Castleton, and Logie. He thought it however probable that ice then floated on the sea, otherwise he could not account for the position of some enormous boulders to the east of Stirling. In the opinion recently expressed, that the last change of relative levels between sea and land had occurred since the occupation of this country by the Romans, he could not concur. Several facts militated against it. If the sea covered the extensive plains to the west of Stirling, up to the old sea-cliff shown on the map, it would have been impossible for the Romans to have had their road, which had been discovered across the moss of Kincardine; or to have had their fort on the banks of the river below Stirling. Moreover, the caves hollowed out by the sea at Wemyss, in Fife, before the last change of the relative levels, must then have been occupied by the sea, and therefore the remarkable sculptures found on their walls, lately described by Sir James Simpson, must have been executed since the Romans left our island, a notion which, he believed, all archæologists would repudiate.

III.—On Carboniferous Fossil Trees Embedded in Trappean Ash in the Isle of Arran.—By E. A. Wünsch, Esq.

THE beds in which these trees occur have hitherto been classified as trap dykes or eruptive sheets of trap rock, but a summer's residence in the island has enabled Mr. Wünsch to discover the true character of the rocks. The beds referred to extend in a north-easterly direction, at an angle of about 37° from high, down to low-water mark, and, doubtless, to some distance below it, with the stems of trees embedded at right angles to the plane of stratification, having retained the original position in which they once grew, and having subsequently been upheaved on the flanks of the granitic nucleus of the island. As many as twelve or fourteen trunks have been observed on different occasions and within a circumscribed area. The stems of the trees are perfectly cylindrical, from 15 to 20 inches in diameter, with their roots extending down into the subsoil—one of them, a *Sigillaria*, must have been a hollow cylinder, through the interior of which several vigorous young shoots had made their way at the time it was suddenly buried by a shower of ash. Another tree must have been perfectly hollow, filled up with *débris* of vegetables and with fir cones. Mr. Binney, who has undertaken to make a more minute examination of the plants, has found specimens of *Sigillaria*, *Lepidodendron*, and a species as yet undescribed. The ash itself is very much indurated, having, in fact, very much the appearance and hardness of ordinary trap rock. So far as known, the

trees referred to are the only instance of Carboniferous trees preserving both their original outline and position and their internal structure.

IV.—On the Age of the Arran Granites. By Dr. J. Bryce, M.A., F.G.S.

THE author began by stating that all the extraordinary phenomena of the geology of Arran arose from the abnormal position of the Granitic nucleus of the north end of the island, which, instead of forming an anticlinal axis, as is usually the case, had broken through the slate band close to its outer edge, within a few yards of the Old Red Sandstone. Within the area of this nucleus are two granites—a fine and a coarse—and beyond the limits of the nucleus, two separate granite tracts—both of the fine-grained variety—one at the outer edge of the Old Red, and the other amid slates and limestones abounding in fossils. The chief question of interest now in regard to the geology of Arran lay in the age of these granites, and the relative position of the two rocks forming the granite nucleus. Dr. Bryce explained that Glen Iorsa, instead of being occupied by the fine variety, as was supposed, exhibits only the coarser kind, while the fine granite occupies the heights on either side, and forms the surface over all the higher interior parts of the nucleus; and, on the south-east of the area, it runs out against the slate, into which it sends veins in the same manner as the coarser kind does on the flanks of Goatfell. He had come to the conclusion that this finer variety was the later of the two, and overlaid the coarser kind, while the two outlying granites of Ploverfield and Craigdhu were of the same age as the fine variety of the nucleus. He adverted to the singular fact that while granite fragments were absent from the Arran conglomerate, small lumps of the Craigdhu granite had been injected into the adjoining conglomerate—probably in a plastic state—quite an exceptional case in the geology of Arran.

Professor Ramsay said that since he first knew the island of Arran, his opinions regarding it, in some respects, had been considerably altered. Since the publication of his book, now long out of print, some things which were there stated in regard to the special Geological features of certain parts of Arran, he certainly did not now consider correct. If he were to write about the granite formation of Arran in particular, there was scarcely a word in that book that he would repeat; he would withdraw every word he had previously said. And if he were now to express his opinion on the granite of Arran, he believed he would be regarded as so heretical by Dr. Bryce and others on the platform, that he thought, for the sake of the harmony of the meeting, the less he said on the subject now the better.

Professor Ansted expressed his opinion that the granite deposits in Arran were not erupted rocks, and said that the evidence in very many cases of granites not having been erupted in the ordinary sense of the word, was so great as to be entirely incontrovertible. There was no such thing as eruptive granite, properly speaking.

Granite was originally a stratified rock, merely changed by intense heat and pressure, and could not, therefore, be said to be eruptive in the usual sense.

Mr. E. A. Wünsch said that he had accompanied Dr. Bryce in his researches, but had arrived at very different conclusions. The position maintained by Dr. Bryce that there were two granites of different ages—the fine grained erupted through the coarse grained—was utterly untenable. All the granites of Arran he believed to be of one age, and the difference in grain was merely owing to the difference in texture of the different strata previous to being metamorphosed into granite.

The President also expressed an opinion that granite is not erupted rock in the ordinary sense of the term.

V.—On the Trap and Granite in the Island of Mull. By His Grace the Duke of Argyll, K.T., D.C.L., F.R.S.

BEN CRAIG, one of the lower shoulders of Ben More, exhibits very clearly the passage of a rock, which looks like pure trap into regular granite. At the base of the shoulder of the mountain, which may be about 2000 feet high, it is a mass of fine-grained compact granite. At the top it is a mass of tuff which weathers white, and has a fracture like some kinds of trap. At an immense elevation this tuff contains many crystals of felspar, very distinctly separated. A little lower down these crystals become more frequent, a granitic rock appears, and then comes the regular granite. His Grace could detect no distinct separation. The top of the mountain is very white, the rock very shattered, some of it very light, with one or two dykes passing through this trap-like mass. The dykes are of a closer texture, with white crystals unlike the surrounding mass. The whole structure of Ben More, in Mull, is full of interest. The summit peak is of stratified rock—mica slate—and all the lower shoulders are granite, or igneous rock *becoming* granite.

VI.—On the Cambrian Rocks of Llanberis. By George Maw, F.L.S., F.G.S.

A CUTTING on the branch railway from Carnarvon, now in course of formation, has exposed the structure of the Lower Cambrian beds, the most complicated part of the series. Underneath the beds worked for slates in the Dinorwic and Glyn Quarries, there occurs a considerable thickness of a trap-like rock, obscurely banded with dark olive green and dull buff, which rests unconformably on the upturned edges of a still more ancient slate rock. Many of the dark-green bands, interstratified with the workable slates of the higher series, and which have been grouped with the Cambrian grits and pebble-beds, contain isolated fragments of altered slate, and wherever they are in contact with the blue or purple slates, a thin course of altered green slate occurs at the junction. Towards the lower part of the upper series in the Glyn Quarries, the green matter occurs as thin bands, in contact with which the slate has been

altered to a pale green in the same way as that adjacent to the intrusive dykes of greenstone. The dark green bands were found on analysis to exhibit a totally different composition to that of the slaty matrix, and appeared to have been derived from a different source. With reference to the condition of fusion, under which the dykes of greenstone were intruded, judging from the kind of alteration produced in the adjacent slate, the heat could not have been sufficient to effect a purely vitreous liquefaction of the traps; and experiments proved that the slaty matrix was fusible at a temperature at which the greenstone remained refractory.

VII.—On the Alteration of the Coast Line of Norfolk. By J. Wyatt, F.G.S.

THIS paper described the result of observation on the changing coast line of Norfolk. The author showed that the geological changes in this part of the island were not all to the loss of the nation, proving that in West Norfolk there was a continual addition to the area. A secondary object of the paper was to enforce the necessity of accurate records of the changes of coast lines, and the author suggested that this should be undertaken by a responsible department of the Government, who should combine the two systems adopted by the Ordnance and Admiralty Surveyors,

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VIII.—Report on Dredging among the Shetland Isles. By J. Gwyn Jeffreys, F.R.S., F.L.S., F.G.S.

THIS, the fourth report by Mr. Jeffreys on dredging in the British seas, as usual contains observations of much interest. Five species are added to the list of British Mollusca, namely, *Terebratella Spitzbergensis*, Dav.; *Rhynchonella psittacea*, Gm.; *Leda pernula*, Müll.; *Siphonodentalium Lofotense*, Sars.; and *Cadulus subfusiformis*, Sars.; and more information is gained on the geographical distribution and habits of the Mollusca. A list of species obtained from a depth of 170 fathoms is given, of which sixteen were living, and thirty-eight dead. The shells were of the usual tints; the notion that colour is absent, or fainter in shells from deep water appeared to be quite unfounded. Relics of the Glacial epoch occurred in 170 fathoms, and higher, up to 80 fathoms; they were—*Pecten Islandicus; Tellina calcaria; Mya truncata*, var. *Uddevallensis; Saxicava rugosa*, var. *Uddevallensis; Mölleria costulata;* and *Trochus cinereus.*

In dredging at a depth of about eighty-five fathoms, on a soft, sandy bottom, twenty-five miles north-north-west of Unst, the canine tooth of an animal of the weasel tribe—probably a ferret—and the shoulder-blade of a bat were brought up. The author is indebted to Mr. Boyd Dawkins for an examination of these remains.
