December 14.—John Samuel Dawes, Esq., of West Bromwich, Staffordshire, Ironmaster; and the Rev. Robert Wallace, of 2 Cavendish Place, Manchester, were elected Fellows of this Society.

A memoir, entitled "On the Ridges, Elevated Beaches, Inland Cliffs and Boulder Formations of the Canadian Lakes and Valley of St. Lawrence," by Charles Lyell, Esq., V.P.G.S., F.R.S., was commenced.

January 4, 1843.—The Rev. William Wilson, B.D. Oxon., Vicar of Walthamstow; James Edward Davis, Esq., of the Middle Temple, Barrister; John Moreton, Esq., of Chester Hill, near Uley, Gloucestershire; and Sir George Lefevre, of No. 2 Porchester Place, Oxford Square, were elected Fellows of this Society.

The reading of Mr. Lyell's memoir, commenced on the 14th of December, was resumed.

After adverting to his former paper on the Recession of the Falls of Niagara, and the observations which he made jointly with Mr. Hall in the autumn of 1841*, Mr. Lyell gives an account of additional investigations made by him in June 1842; in the course of which he found a fluviatile deposit similar to that of Goat Island, on the right bank of the Niagara, nearly four miles lower down than the great Falls. The freshwater strata of sand and gravel here alluded to occur at the Whirlpool. They are horizontal, about forty feet thick, plentifully charged with shells of recent species, and are placed on the verge of the precipice overhanging the river. They are bounded on their inland side by a steep bank of boulder clay, which runs parallel to the course of the Niagara, marking the limit of the original channel of the river before the excavation of the great ravine. Another patch of sand, with freshwater shells, was detected on the opposite or western side of the river, where the Muddy Run flows in, about $1\frac{1}{2}$ mile above the Whirlpool. From the position of these strata it is inferred that the ancient bed of the river, somewhere below the Whirlpool, must have been 300 feet higher than the present bed, so as to form a barrier to that body of fresh water in which the various beds of fluviatile sand and gravel above-mentioned were accumulated. This barrier was removed when the cataract cut its way back to a point further south. The author also remarks, that the manner in which the freshwater beds of the Whirlpool and Goat Island come into immediate contact with the subjacent Silurian limestone, no drift intervening, shows that the original valley of the Niagara was shaped out of limestone as well as drift. Hence he concludes that the rocks in the rapids above the present Falls had suffered great denudation while yet the Falls were at or below the Whirlpool.

Mr. Lyell thinks that the form of the ledge of rock at the Devil's Hole, and of the precipice which there projects and faces down the river, proves the Falls to have been once at that point. An ancient

* See Proceedings, vol. iii. p. 595.

gorge, filled with stratified drift, which breaks the continuity of the limestone on the left bank of the Niagara at the Whirlpool, was examined in detail by the author, and found to be connected with the valley of St. Davids, about three miles to the north-west. This ancient valley appears to have been about two miles broad at one extremity, where it reaches the great escarpment at St. Davids, and between 200 and 300 yards wide at the other end, or at the whirlpool. Its steep sides did not consist of single precipices, as in the ravine of Niagara, but of successive cliffs and ledges. After its denudation the valley appears to have been submerged and filled up with sand, gravel, and boulder clay, 300 feet thick.

A description is next given of certain modern deposits, containing freshwater shells, on the western borders of the Niagara, above the Falls, and in Grand Island, in order to show that the future recession of the Falls may expose patches of fluviatile sediment similar to those in and below Goat Island.

The author then passes to the general consideration of the boulder formation on the borders of Lakes Erie and Ontario, and in the valley of the St. Lawrence, as far down as Quebec. Marine shells were observed in this drift at Beauport, below Quebec, as first pointed out by Captain Bayfield, and also near the mouth of the Jacques Cartier river, and at Port Neuf and other places; also at Montreal, where they reach a height probably exceeding 500 feet above the sea, the summit of Montreal mountain being 760 feet high, according to Bayfield's trigonometrical measurement, and the shells being supposed to be 240 feet below the summit. These shells, therefore, being more than 300 feet above Lake Ontario, we may presume that the sea in which the drift was formed extended far over the territory bordering that lake. The most southern point at which the author saw fossil shells belonging to the same group as those of Quebec was on the western and eastern shores of Lake Champlain, viz. at Port Kent and Burlington, in about lat. 44° 30′. Here, and wherever elsewhere the contact of the drift is seen with hard subjacent rocks, these rocks are smoothed, and furrowed on the surface, in the same manner as beneath the drift in northern Europe. The species of shells occurring in the drift, to which Mr. Lyell has made some additions, are not numerous, and are all, save one, known to exist, but are inhabitants, for the most part, of seas in higher latitudes. Many of them are the same as those occurring fossil at Uddevalla and other places in Scandinavia, and they imply the former prevalence of a colder climate when the drift originated. At Beauport there are large and far-transported boulders, both in beds which overlie and underlie these marine shells.

The author next describes the ridges of sand and gravel surrounding the great lakes, which are regarded by many as upraised beaches. He examined, in company with Mr. Hall, the "Lake ridge," as it is called, on the southern shore of Lake Ontario, and other similar ridges north of Toronto, which were formerly explored by Mr. Roy*,

* See Proceedings, vol. ii. p. 537.

and which preserve a general parallelism to each other and to the neighbouring coast. Some of these have been traced for more than 100 miles continuously. They vary in height from ten to seventy feet, are often very narrow at their summit, and from fifty to 200 yards broad at their base. Cross stratification is very commonly visible in the sand; they usually rest on clay of the boulder formation, and blocks of granite and other rocks from the north are occasionally lodged upon them. They are steeper on the side towards the lakes, and they usually have swamps and ponds on their inland side; they are higher for the most part and of larger dimensions than modern beaches. Several ridges, east and west of Cleveland in Ohio, on the southern shore of Lake Erie, were ascertained to have precisely the same characters. Mr. Lyell compares them all to the osars in Sweden, and conceives that, like them, they are not simply beaches which have been entirely thrown up by the waves above water, but that many of them have had their foundation in banks or bars of sand, such as those observed by Capt. Grey running parallel to the west coast of Australia, lat. 24° S., and by Mr. Darwin off Bahia Blanca and Pernambuco in Brazil, and by Mr. Whittlesey near Cleveland in Lake Erie. They are supposed to have been formed and upraised in succession, and to have become beaches as they emerged, and sometimes cliffs undermined by the waves. The transverse and oblique ramifications of some ridges are referred to the meeting of different currents and do not resemble simple beaches.

The base-lines of the ridges east and west of Cleveland, are not strictly horizontal according to Mr. Whittlesey, but inclined five feet and sometimes more in a mile. Those near Toronto are said by Mr. Roy to preserve the same exact level for great distances, but Mr. Lyell does not conceive that our data are as yet sufficiently precise to enable us to determine the levels within a few feet at points distant several hundred miles from each other. No fossil shells have been obtained from these ridges, and the author concludes that most of them were formed beneath the sea or on the margin of marine sounds. Some of the less elevated ridges, however, may be of lacustrine origin, and due to oscillations in the level of the land since the great lakes existed, for unequal movements, analogous to those observed in Scandinavia, may have uplifted freshwater strata above the barriers which divide Lake Michigan from the basin of the Mississippi, or Lake Erie from Ontario, or the waters of Ontario from the ocean. Considerable differences of level may have been produced in the ancient beds of these vast inland bodies of freshwater, while the modern deposit and the subjacent Silurian strata may to the eye appear perfectly horizontal.

The author then endeavours to trace the series of changes which have taken place in the region of Lakes Erie and Ontario, referring first to a period of emergence when lines of escarpment like that of Queenstown, and when valleys like that of St. Davids were excavated; secondly, to a period of submergence when those valleys and when the cavities of the present lake-basins were wholly or partially filled up with the marine boulder formation; and lastly, to the re-

emergence of the land, during which rise the ridges before alluded to were produced, and the boulder formation partially denuded. He also endeavours to show, how during this last upheaval the different lakes may have been formed in succession, and that a channel of the sea must first have occupied the original valley of the Niagara, which was gradually converted into an estuary and then a river. The great Falls, when they first displayed themselves near Queenstown, must have been of moderate height, and receded rapidly, because the limestone overlying the Niagara shale was of slight thickness at its northern termination. On the further retreat of the sea a second fall would be established over lower beds of hard limestone and sandstone previously protected by the water; and finally, a third fall would be caused over the ledge of hard quartzose sandstone which rests on the soft red marl, seen at the base of the river-cliff at Lewistown. These several falls would each recede further back than the other in proportion to the greater lapse of time during which the higher rocks were exposed before the successive emergence of the lower ones. Three falls of this kind are now seen descending, a continuation of the same rocks on the Genesee River at Rochester. Their union, in the case of the Niagara into a single fall, may have been brought about in the manner suggested by Mr. Hall*, by the increasing retardation of the highest cataract in proportion as the uppermost limestone thickened in its prolongation southwards, the lower falls meanwhile continuing to recede at an undiminished pace, having the same resistance to overcome as at first.

Mr. Lyell considers the time occupied by the recession of the Falls from the Whirlpool to be quite conjectural, but assigns a foot rather than a yard a year as a more probable estimate; thus he shows the Mastodon, found on the right bank near Goat Island, though associated with shells of recent species, to have claim to a very high antiquity, since it was buried in fluviatile sediment before the Falls had receded above the Whirlpool.

"Notice on a Suite of specimens of Ornithoidicnites, or foot-prints of Birds on the New Red Sandstone of Connecticut." By Gideon Algernon Mantell, LL.D., F.R.S.

These specimens were accompanied by a letter from Dr. James Deane of Greenfield, Massachusetts, the original discoverer of the Ornithoidicnites, of which more than thirty varieties had been found, bearing a striking resemblance to the foot-prints of birds. In this letter Dr. Deane gives an account of his discovery of the impressions eight or nine years ago, and which he then communicated to Professor Hitchcock. He remarks, that "the footsteps are invariably those of a biped, and occur on the upper surface of the stratum, while the cast or counter-impression is upon the lower. In some instances we may follow the progress of the animal over as many as ten successive steps." He has seen a course of steps twelve inches in length by eight in breadth, extending several rods. The intervening space

* Boston Journ. of Nat. Hist., 1841.