

## ROYAL SOCIETY.

*Feb. 28.—Observations on the Parallel Roads of Glen Roy and of other parts of Lochabar, with an attempt to prove that they are of marine origin.* By CHARLES DARWIN, Esq., M.A.

The author premises a brief description of the parallel roads, shelves, or lines, as they have been indefinitely called, which are most conspicuous in Glen Roy and the neighbouring valleys, referring for more detailed accounts to those given by Sir Thomas Dick Lauder, in the Transactions of the Royal Society of Edinburgh, and by Dr. M'Culloch, in those of the Geological Society of London. Both these geologists endeavour to explain the formation of these shelves, on the hypothesis of their resulting from depositions of the margin of lakes, which had formerly existed at those levels. The author however shows that this hypothesis is inadmissible, from the insuperable difficulties opposed to any conceivable mode of the construction and removal, at successive periods, of several barriers of immense size,

whether placed at the mouths of the separate glens or at more distant points. He does not, however, propose the alternative that the beaches, if not deposited by lakes, must of necessity have been formed by channels of the sea, because he deems it more satisfactory to prove, from independent phenomena, that a sheet of water, gradually subsiding from the height of the upper shelves to the present level of the sea, occupied for long periods, not only the Glens of Lochabar, but the greater number, if not all, the valleys of that part of Scotland, and that this water must have been that of the sea. It is argued by the author, that the fluctuating element must have been the land, from the ascertained fact of the land rising in one part, and at the same time sinking in another; and therefore, that this change of level in Scotland, attested as it is by marine remains being found at considerable heights both on the eastern and western coasts, implies the elevation of the land, and not the subsidence of the surrounding waters. The author next shows that in all prolonged upward movements of this kind, it might be predicted, both from the analogy of volcanic action and from the occurrence of lines of escarpment, rising one above the other in certain regions, that, in the action of the subterranean impulses, there would be intervals of rest. On the hypothesis that the land was subjected to these conditions, it appears that its surface would have been modelled in a manner exactly similar, even in its minute details, to the existing structure of the valleys in Lochabar. Considering that he has thus established his theory, the author proceeds to remove the objections which might be urged against its truth, derived from the non-extension of the shelves, and the absence of organic remains at great altitudes. He then shows how various details respecting the structure of the Glens of Lochabar, such as the extent of corrosion of the solid rock, the quantity of shingle, the numerous levels at which water must have remained, the forms of the heads of the valley, where the streams divide, and especially their relation with the shelves, and the succession of terraces near the mouth of Glen Spean, are all explicable on the supposition that the valleys had become occupied by arms of a sea which had been subject to tides, and which had gradually subsided during the rising of the land; two conditions which could not be fulfilled in any lake. From the attentive consideration bestowed by the author on these several and independent steps of the argument, he regards the truth of the theory of the marine origin of the parallel roads of Lochabar—a theory of which the foundation-stone may be said to have been laid by the important geological researches of Mr. Lyell, establishing the facts of continents having slowly emerged from beneath the sea—as being sufficiently demonstrated. The author states, in the concluding part of his paper, the following as being the chief points which receive illustration from the examination of the district of Lochabar by Sir Thomas Dick Lauder, Dr. M'Culloch, and himself. It appears that nearly the whole of the water-worn materials in the valleys of this part of Scotland were left, as they now exist, by the slowly retiring waters of the sea; and the principal action of the rivers since that period has been to remove such deposits; and, when this had been effected, to excavate a wall-sided gorge in the solid rock. Throughout this entire district, every main, and most of the lesser inequalities of surface are due, primarily, to the elevating forces, and, secondarily, to the modelling power of successive beach-lines. The ordinary alluvial action has been exceedingly insignificant, and even moderately sized streams have worn much less deeply into the solid rock than might have been anticipated, during the vast period which must have elapsed since the sea was on a level with the upper shelves: even the steep slopes of turf over large spaces, and the bare surface of certain rocks, having been perfectly preserved during the same lapse of time. The elevation of this part of Scotland, to the amount of at least 1,278 feet, was extremely gradual, and was interrupted by long intervals of rest. It took place either during the so-called "erratic block period," or afterwards; and it is probable that the erratic blocks were transported during the quiet formation of the shelves. One of these was found at an altitude of 2,200 feet above the present level of the sea. The most extraordinary fact is, that a large tract of country was elevated to a great height, so equably, that the ancient beach-lines retain the same curvature, or nearly so, which they had when forming the margin of the convex surface of the ancient waters. The inferences drawn by the author from these facts, and which he corroborates by other evidence, are, that a large area must have been uplifted, and that its rise was effected by a slight change in the convex form of the fluid matter on which the crust of the earth rests: and therefore that the fluidity of the former is sufficiently perfect to allow of the atoms moving in obedience to the law of gravitation, and consequently of the operation of that law modified by the centrifugal force: and lastly, that even the disturbing forces do not tend to give to the earth a figure widely different from that of a spheroid in equilibrium.