XI.—*A Letter to Charles Lyell, Esq., on some Changes of Level which have taken place in Denmark during the present period.*

By GEORGE FORCHHAMMER, Phil. Doct., For. Mem. G.S.

[Read May 31, 1837.]

MY DEAR SIR,

THE great interest which you have taken in the geology of Denmark, and the influence which you have exerted on the whole progress of geology, more especially of that portion which relates to our knowledge of the newer formations, make me wish to communicate, through you, some facts which appear to me worthy of being known to a Society, which has so much promoted our science.

You are satisfied that a great part of Sweden is rising, not uniformly, but in a manner which generally decreases in amount from north to south on the Swedish coast of the Bothnian Gulf*; and in your last anniversary speech you have published some observations by Mr. Nilsson on the subsidence of Scania, the southernmost part of Sweden†. Thus it appears to be proved, not only that the elevation varies in different places, but that even a movement in an opposite direction takes place in some parts of this extensive country. In corroboration of these facts, I will only mention, that the island of Saltholm, situated in the Sound, and opposite to Copenhagen, is mentioned in the records of the Chapter of Roeskilde in the 13th century, on account of the income which the clergy derived from it. At present the island is hardly five feet above the level of the Sound, and it is almost every autumn overflowed by the sea, some artificial mounds serving as places of safety for the cattle which in summer graze on the island. Now it is evident, that if Saltholm has risen during the last 600 years, the movement must have been at a much slower rate than even in the island of Bornholm, which rises about one foot in a century; and considering how small a portion of Saltholm would be left if it now subsided only two feet, the island would hardly have been worth the notice of the rich Chapter of Roeskilde; we may therefore fairly infer that Saltholm either has been stationary or may have subsided during the last 600 years.

* Phil. Trans. 1835.

† Proceedings Geol. Soc., vol. ii. p. 506.

On the Danish coast of the Sound, six miles to the north of Copenhagen, a most decided beach occurs about six feet above the level of the present Sound, and so completely out of the reach of the sea, that a range of houses has been built between the ancient beach and the present shore. This renders it highly probable that the level on the Danish coast changes in a proportion different from that which takes place on the Swedish shore; and this difference seems to be connected with the fact, that the slight earthquakes which are felt in Sweden almost every year are never experienced in Denmark, and that a shock of an earthquake which in August 1829 was felt so strongly on the Danish coast of the Sound, that the terrified fishermen in some places left their houses, was not at all perceived on the opposite Swedish shores.

I will, however, not dwell on these points, but proceed to detail my observations on the island of Bornholm, the rocky base of which makes a change of level more easily to be observed. The greater part of Bornholm consists of a granitic rock, which forms the whole eastern shore of the island, and rising abruptly out of the water, the sea is so deep that it generally allows large vessels to lie close to the shore. To the height of 250 feet, the granite is covered by a stiff, loamy soil; but above that level nothing is found except barren gravel, the result of the disintegration of the granite. The yellow loam everywhere contains fragments of slates and transition limestones, the latter possessing the character by which they are easily proved to have been transported from the island of Gothland. None of the plutonic rocks, so common in our boulder formation, are to be found here; and by their absence and the frequent occurrence of the clay slates, which are extremely rare in the boulder formation, this bed is proved to be of a different origin. It is not a sea-beach, all the stones being completely mixed with the clay, and on the west side of the granitic ridge no trace of it can be found. These observations lead me to conclude that the bed of loam is the result of a violent inundation breaking in from the north-eastern parts of the Baltic, the effect of which may be seen everywhere, both in the form of the Danish shores and the immense deposits of sand which cover a great part of Denmark, and which evidently have been swept away from more easterly beds of the boulder formation.

Nearer to the present shore (see accompanying woodcut), at a height of about forty feet, the first beach may be observed on Bornholm. Wherever the granitic mountains recede a little from the coast and form a small bay, the granite pebbles of the beach appear to have choked it up, and to have separated a small pond from the sea, which in the course of ages has been filled with peat. This ridge has only a small breadth and slopes towards the shore at an angle of 15° , forming a wall of about ten feet high, and abutting on a plain entirely formed of beach-stones. This plain is completely horizontal and has a breadth of about 160 feet. It is surrounded by another plain of about 100 feet broad, inclining toward the sea at an angle of 9° or 10° , to which succeeds the present beach, sloping at an angle of 12° or 13° ; the pebbles are of uniform size throughout the beach, and consist of the same granite as the solid rock. My explanation of these facts is the following: after the inundation before mentioned, and which I conceive entirely changed the face of Bornholm and the rest of Denmark, a beach was produced at the shore, but I infer that its accumulation was interrupted by an earthquake, which suddenly threw up the island about ten feet; and that a very long period of perfect quiet followed, during which no elevation took place, but the horizontal beach was formed. Subsequently I am of opinion a continuous but very slow rising began, which formed the sloping beach; and, according to observations of the inhabitants and my own, this rising is still in progress. On this sloping beach are graves marked merely by a ring of stones, a little larger than the general size of the beach-stones, and very different in structure from the graves which our heathen ancestors erected. Now, according to a communication from Mr. Finn Magnussen, it was a custom in the northern countries to bury the early Christians on the beach where the sea and land separated, and when afterwards the Christians got the power, the same kind of sepulchre was used for the heathens. This happened about the year 900, and we may consequently come to something like a rough calculation as to the time when this beach was formed. The elevation of the island, as shown by the sloping beach, would thus have been about one foot in a century, and the beginning of the regular elevation of the island would have been about 1600 years ago. The slope being completely regular, it is most probable that the rise of the island and the lateral addition to the beach were quite uniform during the whole period; and by supposing this lateral extension to have been equally uniform during the formation of the horizontal beach, we require 2500 years for the gradual accumulation of the horizontal beach, which carries back the era of the great earthquake to about 4000 years before our time. I do not pretend to say that this chronological calculation can be by any means exact, yet I think it may be of some use; and future observers on Bornholm, availing them-

selves of the facts which I have tried to point out, may certainly bring the calculation much nearer to the truth.

The features of the beach now described, occur, with some small differences, everywhere on the granitic, eastern shore of the island ; but wherever the coast is formed of sandstones and slates of the transition-class, or of the beds of sandstone, sand, clay, and limestone, belonging to the lias, the oolitic series, and the green-sand formation, no regularity in the beaches can be traced, nor can any one be seen more than twenty feet above the present level of the sea ; and it seems as if these formations have suffered a less regular elevation than the granite.

Over the whole of Denmark, Sleswick, and Holstein, shells of species living at the present time in the German Ocean may be found, sometimes at considerable heights above the level of the sea. Thus not far from Bornhövd in Holstein, certainly exceeding 150 feet above the Baltic, occurs a bed of pebbles associated with *Cardium edule*, *Littorina littorea*, *Buccinum undatum*, and *Ostrea edulis*. The specimens of the last shell are much smaller than the *O. edulis* now living on our coast, but they agree with those found fossil in the raised beds of recent marine shells of England. Thus the elevation of the country in modern times is certainly proved, but this elevation must be much older than the inundation from the east before mentioned. After that catastrophe subsidences occurred, of which I will mention one with rather interesting features ; between the island of Römöe and the shores of the dukedom of Sleswig, is a submarine forest nine feet below the present high water, the roots still branching out into the sand. According to the evidence of all the fishermen, this forest consists of fir, a tree which likewise occurs in almost all our peat-mosses, being the oldest vegetation. At other places far beyond the present shore, forests of oak are found in the same situation below the mean height of the sea.

Before I conclude this letter, I wish to record the following phænomena. On the islands on the western shore of Sleswig traces of an inundation may be found to the great height of about sixty feet above the present high-water mark, which happened while the islands have been inhabited by man, because we find tumuli partly destroyed by the inundation. The effect and height of this flood may easily be traced by a bed of pebbles, partly rounded, partly angular, containing now and then fragments of bricks, and easily distinguished from a beach by its occurrence in one single bed hardly a foot thick, undulating with the surface, and in one place found only a few feet above high-water mark, while at others it is about fifty feet above it. I consider it as the result of the washing away of the finer materials, or the sand and sandy clay.

London, March 20th, 1837.

G. FORCHHAMMER.