21. *On some LANDSLIPS in BOULDER-CLAY near SCARBOROUGH.* By
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June 5th, 1901.)

IN the valleys which have been cut through the tabular Howardian Hills, and on the hills themselves, there is a great scarcity of deposits of Drift, but along the Yorkshire coast we find a remarkable band of Boulder-Clay with an average width of about 2 miles. The consequence is, that whereas inland the solid rock (Corallian, Oxfordian, etc.) is exposed from the top of the hills to the bottom of the valleys, along the coast the old pre-Boulder-Clay surface of the ground is obscured, and only the higher points of solid rock, such, for instance, as Oliver's Mount, project through the Boulder-Clay covering.

The old surface-features of the ground have been to some extent exposed by the action of the sea. Thus the old Corallian-capped hill upon which Scarborough Castle stands has been worn out of the Boulder-Clay in process of denudation, and even now a capping of that clay remains on its top.

South of the castle there was in pre-Boulder-Clay times a deep valley; for the Drift has been penetrated to a depth of over 100 feet below sea-level,¹ and this valley has been to a certain extent re-excavated by the stream which flows from the Mere.

The south side of the valley was formed of sandstones belonging to the Estuarine Series, which at High Wheatcroft are covered by Cornbrash and Kellaway's Rock; but beyond White Nab we come to another old depression, which is cut through by the sea in Carnelian Bay. The depression sinks very little below high-water mark, but no doubt it may be the upper part of a valley running in a westerly direction to join the old River Derwent. Even now the stream rising so near the cliffs as Low Wheatcroft flows in a westerly direction to the Hertford River.

Carnelian Bay, which scarcely deserves the name of bay, comprises the coast between White Nab on the north and Osgodby Nab on the south. The Oolitic rocks (Scarborough Limestone and Estuarine Series) form the lower half of the cliff at White Nab, and the old pre-Drift surface slopes down towards the south, and a little north of Osgodby Nab it sinks below sea-level.

The present surface of the ground is, however, fairly uniform—being, indeed, a flat with a slight inland slope,—and consequently the Drift, a mere capping 6 feet thick at High Wheatcroft, thickens till it forms half the cliff at White Nab, and the whole of the cliff in the southern half of Carnelian Bay. From this flat a broken ridge runs out in the middle of the Bay, and a spur also projects towards Osgodby Nab.

¹ C. Fox-Strangways & G. Barrow 'Geology of the Country between Whitby & Scarborough' Mem. Geol. Surv. (1882) p. 51.

Fig. 1.—*Carnelian Bay, Scarborough.*

Fig. 2.—*Slipped Boulder-Clay in Filey Bay.*

[The surface of cliff represented measures about 15×24 feet.]

Fig. 1 is a reproduction of a photograph taken by myself on September 26th, 1896 (Brit. Assoc. Coll. of Photos. 2483). It was taken from the shore a little north of Osgodby Nab, the camera pointing in a direction a little west of north. The rock of Scarborough Castle forms a prominent object in the distance. On the right there is solid rock, a reef of sandstone below high-water mark; and on the left is a low cliff of Boulder-Clay, all of which has slipped down from a higher level.

When the clay is dry it has a tendency to crack vertically, and a sort of columnar structure is produced. The large pillar of clay seen in the view was, I believe, due to the action of the waves on clay with such vertical cracks.

I have for several years noted details of landslips in the Drift near Scarborough, and, as in other cases,¹ they may be classed as :

- (1) Mud-flows.
- (2) Earth-slips where the clay, though not actually mud, is at least partly in a plastic condition.
- (3) Falls which, owing to the dryness of the clay, resemble rock-falls.

(1) I have only seen small mud-flows in Carnelian Bay; but some years ago I came upon one flowing across the footpath to Filey, near Yons Nab. It was of considerable size; in fact, I did not venture to cross it.

(2) Landslips of clay in a more or less plastic state are very common. I have already said that a columnar structure is set up in the dry clay, and after wet weather masses of this columnar clay slip forward, and the columns become curved and distorted.

During the slipping process a horizontal lamination is often produced in the moister part of the clay, and very pretty twisted structure may be observed which reminds one of gneissic banding. An example of 'augen'-structure in the Contorted Drift at Beeston, on the Norfolk coast, has been photographed by Mr. Strahan and described by Mr. Clement Reid.² A somewhat similar example is shown in fig. 2, reproduced from a photograph which I took on September 15th, 1900. It represents an area of about 360 square feet of the bottom of the cliff a little south of Filey. It will be noticed that the clay in this view, as well as in fig. 1, is full of boulders.

(3) When I was at Scarborough in May of the present year, I was told that a considerable landslip had occurred in Carnelian Bay. I believe that it happened on Whit Sunday, May 26th; I visited the Bay on the 28th, and found that the slip was in the nature of a rock-fall.

It originated from the spur of Drift which I have mentioned as running out from the Boulder-Clay flat towards Osgodby Nab. The Drift consists mainly of Boulder-Clay, but in places there is some

¹ Compare A. Baltzer's 'Ueber Bergstürze in den Alpen' Zürich, 1875 (reprinted from the *Jahrbuch des Schweiz. Alpenclub*, vol. x).

² *Proc. Geol. Assoc.* vol. xiii (1893) p. 66.

sand, and here and there a little gravel. There had been a long spell of dry weather, and the clay was hard and dry. Some rain fell on the Sunday, but whether it was in any way the cause of the slip I do not know. The slipped material appeared to be wholly Drift; the central part had travelled farthest, leaving a long deep depression behind it, and into this the sides had to some extent fallen.

On the solid clay at the sides of the slip were well-marked longitudinal striæ; in places I noticed a cross-striation on a small scale, and on a very few of the fallen blocks of clay striation could be seen. There was a certain amount of sand in the slipped material, but it consisted mainly of blocks of clay of all sizes and shapes: the largest blocks being at the back of the mass. The slipped mass projected on to the foreshore well below high-water mark, the front of the slip on the foreshore being about 200 yards from the ridge whence it started.

DISCUSSION.

Mr. HUDLESTON said that he had no intention of offering any critical remarks on the Author's paper. The excellent illustrations shown on the screen called to mind many a well-known spot on the Scarborough coast, where the Jurassic rocks are in places so much obscured by Boulder-Clay. Without giving any opinion as to the cracks mentioned by the Author, he could not help noting a resemblance to glacier-ice in the behaviour of much of this Boulder-Clay, where crevasses and pinnacles of stony drift, weathering into fantastic shapes, remind one of similar features in Alpine regions.

The PRESIDENT also spoke, and the AUTHOR replied.