

## THE LANDSLIP AT SANDGATE.\*

By W. TOPLEY, F.R.S.

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THE coast of Kent, from Hythe to Abbotscliffe (halfway between Folkestone and Dover) has long been noted for landslips. Measured along the shore this is a distance of eight miles, and in this distance there is probably in all not more than one mile in which the beds along the sea front are normally in place. There has been a general slipping seawards over the various clays—Gault on the east of Folkestone; Sandgate Beds between Folkestone and Shorncliffe; Atherfield Clay to the west. The slips over the Atherfield Clay extend westwards along the Lower Greensand escarpment to Lymne. Here the old Roman fortress of Studfall Castle, built on the slope of the escarpment, has been destroyed by a landslip, the ruins being spread about on the irregular ground formed of Weald Clay. An interesting account was published of a slip near Lymne in 1725, which occurred during a very wet season. The side of the hill gave way, "raising by that means the flat at the bottom and letting the brow, with the farm house upon it, sink 40 or 50 feet at least. What is remarkable it sunk in one night, and so gently that the farmer's family were ignorant of it in the morning when they rose, and only discover'd it by the door-eaves, which were so jamm'd as not to admit the door to open." †

All the Atherfield Clay outcrop east of Lymne has slipped; some small slips took place near Hythe at the same time as the Sandgate landslip. Between Hythe and Shorncliffe the whole cliff has slipped; the Hythe Beds capped by Sandgate Beds are exposed in a quarry on the west of the Seabrook Valley, but much below their normal level, the whole line of cliff having slipped over the Atherfield Clay, whilst the Sandgate Beds have also slipped on themselves.

Passing by Sandgate for the present we may note some important slips on the west of Folkestone, one of which occurred in the early part of the last century and was described in the *Phil. Trans.* ‡ The Folkestone Beds here form the upper part of the cliff; the Sandgate Beds the lower part; the Hythe Beds appearing on the foreshore. The cliff sank about 40 feet, and the

\* This paper was illustrated by a series of lantern slides, kindly lent by Mr. R. Kerr F.G.S., of Folkestone.

† Rev. W. Gostling, *Gentleman's Mag.*, vol. xxvi, p. 160, 1756. The letter was written in 1727. See also P. Collinson, *Phil. Trans.*, vol. xxxv, p. 551, 1728. For description of other landslips in the Weald, along the Lower Greensand escarpment of Kent and the Upper Greensand escarpment of Hants, see "Geology of the Weald," pp. 316-319, 1875.

‡ Rev. J. Sackett, vol. xxvi, p. 469, 1716. *E. King*, vol. lxxvi, p. 224, 1786.

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movement forced up the rocks on the shore, where they are now seen to have an abnormally high dip.

The most important landslip along this coast is that of the Warren, between Folkestone and Dover. The Gault of Copt Point dips gently toward the north-east, and passes under the Chalk along the foreshore. The exact line of outcrop cannot be accurately determined in consequence of the great amount of slipping. The Upper Greensand is here locally developed as a clayey sand, and this may aid the slips by holding some water. The Warren extends from the mouth of the Martello Tunnel to Abbotscliffe, a distance of  $1\frac{5}{8}$  miles, and has an average width of about  $\frac{1}{4}$  mile. The whole of this is a slipped and tumbled mass of Chalk.

In February, 1877, some serious slips occurred here. The first was at the east end of the Martello Tunnel, where an area of about 100 acres slipped along and over the railway. The cutting, 100 feet deep, was filled with fallen chalk for a length of about 200 yards. The pressure of this movement forced up the Gault on the beach in mounds 6 or 7 feet high.

Two days afterwards another serious slip occurred at the east end of the Warren, where the line was again blocked. These slips followed heavy rains in January, the rainfall being about double the average. Similar falls occurred about the same time at the Undercliff in the Isle of Wight.

In March, 1881, another slip occurred in the Warren.

Mr. Price\* has recorded a slip which took place at the west end of the Warren in January, 1886. The area affected was about one mile in length, and the beds were forced up all along the shore opposite the slip: near the east end of the slip the Chalk was forced up nearly 20 feet, and at one place the Gault was raised into hillocks several feet high. This was a very wet month, the rainfall in East Kent being more than in any year since 1877.

In order to render the Warren less insecure, the S.-E. Railway has under-drained it. Galleries are driven in from the sea, and a horizontal tunnel is carried under the landward side of the undercliff. A large quantity of water finds its way into these galleries, discharging direct into the sea.

In November, 1892, a slip in the Gault occurred near the Warren Inn, which carried the roadway down about 40 feet.

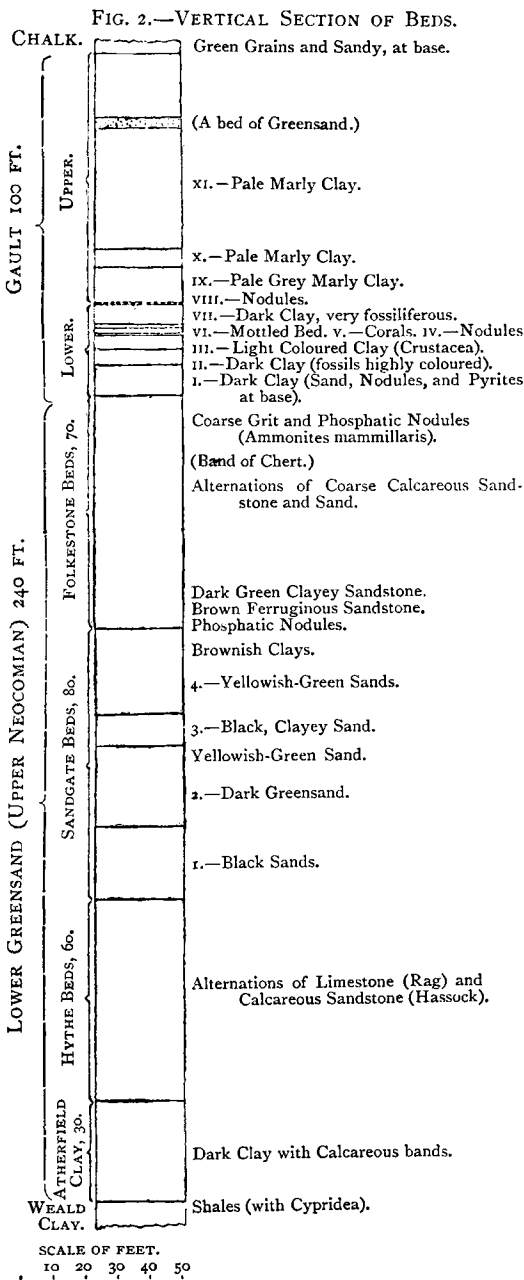
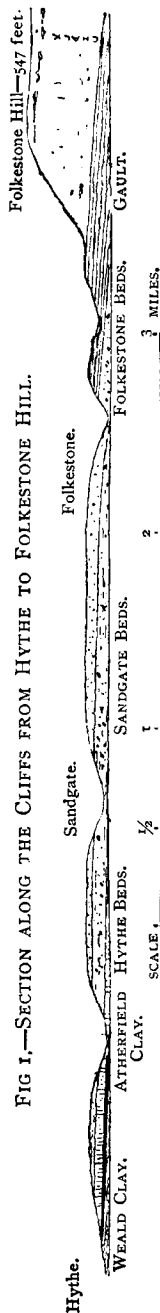
In December, 1839, at about the same time as the great landslip at Lyme Regis, there was a slip at the Warren.

We may now return to Sandgate and consider the geological conditions which have determined the recent landslip there.

The Sandgate Beds consist of various beds of clayey sand, some more clayey than others, but probably not any of it is a completely retentive clay. This series may be about 80 feet in

\* Geol. Mag, 1886, p. 240.

## SECTIONS ILLUSTRATING THE GEOLOGY OF HYTHE AND FOLKESTONE.



thickness; the beds can best be seen under the cliff on the west of Folkestone and again in the cuttings and quarries west of Sandgate. At Sandgate itself there are but few exposures and none in an undisturbed condition, as the whole of the sea-front here is a landslip.\*

The Hythe Beds are seen on the shore east of Sandgate with a dip to the N.N.E., and again opposite the middle of Sandgate with a dip in the same direction, but when last seen on the east of Sandgate the strike is turning round to about E. and W., and a very slight change of dip would carry the beds below sea-level in front of the eastern half of Sandgate, where no rocks occur down to low water mark.

The Hythe Beds rise above the shore at the western end of Sandgate, and were formerly quarried there, Wellington Terrace being built on an old quarry. But the beds are not now seen, except on the shore, being everywhere covered by the fallen masses of Sandgate Beds.

In nearly all exposures on the shore, the rocks have an abnormally high dip, often from  $20^{\circ}$  to  $30^{\circ}$ , and in places as much as  $50^{\circ}$  to  $60^{\circ}$ . These dips are probably due to old slips, the pressure of the moving mass of land forcing up the rocks along the shore. Similar high dips are constantly seen in front of landslips.

A band of clay is seen on the shore, with the Hythe Beds dipping apparently over and under it. This strongly resembles Atherfield Clay, especially in the brown colour of its more weathered parts: it seems to be a stiffer clay than any in the Sandgate series; but how it comes in that position is not clear. It may be due to movements of the rocks caused by old landslips, or it may be due to a strike-fault. This clay is not noted on the Survey Map; at the time when this area was surveyed the shore was much more extensively covered with shingle than now, and the clay was probably rarely exposed.†

There is a disturbance in the Hythe Beds at Horne Street, in the Seabrook Valley, which strikes S.  $32^{\circ}$  E. If this is a fault, and not a mere local disturbance of the Kentish Rag, it may range towards the clay-bed on the shore.

With this exception I do not see that the Survey Map, constructed by Mr. F. Drew (and published in 1863), needs correction, nor can I see any evidence for the faults suggested by Prof. Blake in his recent papers on Sandgate.‡

The groyne south-west of the hospital is entirely built on clay;

\* The details of the vertical section, Fig. 2, p. 42, are from Mr. Price's paper, *Proc. Geol. Assoc.*, vol. iv, p. 135 (1875).

† The clay was not seen by Fitton, who describes the beds along the cliffs and shore in great detail; but in a footnote (p. 124) he says, from information supplied to him, that the clay was exposed in 1833: "It is very marly, and includes a great quantity of wood and pyrites, and in places resembles the Gault of Eastware Bay."

‡ Nature, March 16th; The Surveyor, March 30th, 1893.

this is no doubt the Atherfield Clay, in its normal position below the Hythe Beds.

The higher part of the cliffs behind Sandgate are composed of Folkestone Beds; the junction of the two sets of strata, Folkestone Beds on Sandgate Beds, can be traced round the Enbrook Valley without a break; there is no evidence here of a fault. The whole town of Sandgate is built on a tumbled mass of Sandgate Beds, formed by a series of landslips. The evidence of this was well seen, during March of this year, in a deep cutting for a sewer. Under 8 feet of greenish Sandgate Beds there was a mass of peaty stuff with roots and leaves of recent plants. Many of the houses built on the hill have had to be taken down because of the slow movements of the ground. The eastern half of the area was deeply drained about 40 years back to intercept the underground water, and to render the ground less insecure. This drain passes under the area known as the Undercliff, and ends in the west, just at the east end of Encombe Grounds, exactly where the recent slip commences. The land about the Undercliff was very wet and boggy; but the drain referred to greatly improved it, and this part of the town has of late years shown no signs of movement. There was a slip here in the year 1827.

From the east end of Encombe Grounds the recent slip extended westwards to the Military Hospital. Here a deep cutting for a sewer was made many years back, which has no doubt given a free passage for surface water. To the west of the sewer the land is Government property, and this has been properly drained. Between the Hospital and the east end of Encombe Grounds the land has not been drained, and it is only within this undrained area that the recent slip took place.

The recent slip extended for a length of about 920 yards; it had a maximum breadth of about 233 yards measured from the back of Encombe Grounds to high-water mark; but the foreshore here was also moved for a breadth of about 100 yards.

The greatest vertical movement, at the western part of Encombe Grounds, seems to have been about 10 feet; but the total amount of various small slips at the east end of the grounds is perhaps almost as great. The horizontal movement is small; it may perhaps have amounted to a total of some few feet in parts of the Encombe Grounds, where many slips occur close together; but in the lower parts and along the sea-front it is much less.

The movement was very gentle. Greenhouses were wrecked; but most of the glass was unbroken. Several houses are badly shaken, but no dwelling-house fell. Some are more seriously impaired than appears from a casual inspection outside, the foundations having been greatly damaged.

Some interesting facts were observed where the slipped faces

of clay were fresh ; they were streaked with true slickensides running obliquely down the face. The eastmost end of the slip is a nearly straight line running S.E. from the east end of Encombe Grounds. There are always small slips at this end of the Grounds about this time of year. Some were noticed a few days before the big slip occurred.

There has been considerable movement on the shore. One wooden groyne, opposite Littlebourne Lodge, has been snapped across by the moving land, the lower part of the groyne having stood fast against the Hythe Beds, while the upper part was pushed slightly towards the west. The maximum movement seaward of the sea-wall is about opposite this groyne, at the most it does not exceed 18 inches. The groyne next to this on the east has apparently not moved, or if so it has moved bodily without displacement. The next groyne has been forced up about 4 feet in its lower part ; and the same thing has happened to the sewer-outfall opposite Camp Road.

The band of clay opposite Gloucester Terrace and Wellington Terrace was forced up ; the movement continuing during the Monday and perhaps later. Mr. R. M. Jenner, of Sandgate, who examined the shore at daybreak on Sunday morning, tells me that the whole of this clay was in motion, the blocks of stone lying on it being slowly lifted up and turned over.\*

The groyne opposite the Coast Guard Station has been pushed up a little ; some change also took place at the end of this groyne, for before the slip a boat could get round the end of the groyne at low water, which cannot be done now.

As a rule the houses built of wood have stood best ; brick houses come next, but there are comparatively few of these. Stone houses as a rule have stood worst, but this is because they have been badly built, the stones being only roughly cemented and no attention having been paid to the binding. The front of Spring House is of brick ; this has given way, bending over to the east, its weight being supported by Spring Cottage, which is built of wood. The back of Spring House is well constructed of stone ; and this has scarcely moved.†

A new brick house, strongly built, stands on the site of the west end of Encombe House, which was taken down some years back. This new house is uninjured, there being only a few small cracks in its southern front and signs of a slight movement at its north-western corner, but the stable yard against the southern front is badly cracked, and the stables, only a few yards off, are much damaged.

I have already referred to the fact that the amount of shingle

\* I am greatly indebted to Mr. Jenner, and to Mr. A. G. Sellon, of Sandgate, for much information about the landslip, and for other facts of interest relating to the district.

† For these facts I am indebted to the kindness of Mr. A. Bromley, Architect, of Folkestone, who has reported to the Local Board of Sandgate on the damage done to houses in the town.

in front of Sandgate is much less now than it was some years back. When the Ordnance Survey was made in 1871, the "High Water Mark of Ordinary Tides" was 45 feet from the sea-wall opposite the Coast Guard Station, and from 60 to 70 feet at the west end of the town. In consequence of extensive groyning to the west of Sandgate, the eastward travel of shingle was stopped and the sea-front of Sandgate became almost bare of shingle, the sea-wall was partly destroyed, and a small tract of land near the sluice of the Military Canal was washed away. The sea wall was repaired a few years back, and new groynes were made, the result being that the shingle is now again slowly accumulating.

The loss of shingle has no doubt rendered the land more insecure, there being less permanent weight on the foreshore. The recent slip commenced at about low spring tide on the evening of March 4th; the movement diminished as the tide rose, although not entirely ceasing, and at low tide next morning a second slip took place.\*

The extensive slips at the Warren have no doubt been much aided by the absence of shingle; there used to be a continuous bank of shingle with a cart-road on it, from Folkestone to Dover. The harbour works and the jetty at Folkestone have arrested the shingle there, and the ground in front of the Warren is now practically bare of shingle. The sea undermines the cliff and thus aids the landslips. At Sandgate the sea-wall prevented any direct damage to the town from the want of shingle.

Much water drains away along the shore at low tides: this generally contains some fine sand washed out of the fallen Sandgate Beds behind the town. The constant loss of the sand must tend to make the ground more liable to slips.

Much has been said as to the damage which may have been done to the land by the blowing up of the *Calypso* (by dynamite) in June, 1891, and of the *Benvenue* (by nitro-glycerine, gun-powder, etc.) from September to December, 1892. The *Benvenue* was wrecked 450 yards from the sea-wall opposite Littlebourne Lodge, near Wellington Terrace; the *Calypso* was about half a mile from the shore opposite the Battery Steps, beyond the west end of the town. A pond east of the Encombe Grounds was suddenly drained at the time of the *Calypso* explosions: a crack opened at the bottom of the pond and fish there got away which were taken out of the crack lower down the hill. The cellar of Salem House, near the Convalescent Home, is said to have been thus flooded. A house in Gloucester Terrace is said to have cracked, and the roofs of other houses were damaged. These

\* The Rev. E. Hill in his description of the Zug landslip, July 5th, 1887, attributes this in part to the unusually low level of the lake, *Rep. Brit. Assoc.*, for 1887, and *Geol. Mag.*, 1887, p. 473.

appear to be the only evidences of the effect of this explosion. The pond and Salem House are not within the area affected by the recent slip, but Gloucester Terrace is within it. The vibrations caused by the *Calyпсо* explosions are said to have been more felt than those of the *Benvenue* although much farther off and probably on Weald Clay. The *Benvenue* vibrations as felt at the Coast Guard Station were not greater than those caused by heavy gales at high spring tides. It is impossible to say that these explosions had no effect in rendering the ground more insecure ; but sufficient other cause for the landslip can be found.

The rainfall of February was unusually heavy. Mr. Mackeson's rain-gauge at Hythe registered 4·3 inches in that month, 24 out of the 28 days being wet ; 1·06 in. fell on one day (Feb. 21st). The average February rainfall for the ten years 1883-92 was 1·95 in., with 13·8 wet days.\*

The whole evidence points to the fact that the slip was due to the great accumulation of water in the broken mass of Sandgate Beds caused by the excessive rainfall of the preceding month. The slipped area is not drained, whereas the districts immediately east and west of it are drained, and this renders them comparatively safe. Mr. Baldwin Latham, who is advising the Local Board on the subject, recommends a deep drain at the back of the landslip to catch all water coming from the Folkestone Beds of the hills behind. This is certainly the proper step to take, and it will no doubt render any such calamity as that now described very improbable in the future.

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\* In Symons' "Monthly Meteorological Magazine" for March there is an account of "The Sandgate Disaster," giving the February rainfall for East Kent. The fall varied, at six stations from 3·06 to 4·3 in. ; that at Hythe being the largest.