The Sandgate Landslip

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General of British Bechuanaland. That of Morokweng was fixed by chronometer, and is the mean of two visits. Since the publication of his map in *Petermann's Mittheilungen*, Mr. Wilkinson has thought it necessary to allow a somewhat different rate for his chronometer, and has recalculated the longitudes, but they must only be regarded as approximations. Latitudes were fixed by observations for meridian altitudes of the sun. The altitude of Maralilen on the map in *Petermann* ($25^{\circ} 39' \text{ S.}$), is from an observation taken in 1889. In 1891, however, when they reached Kesa from the south, a native who had recognised them, assured them that Kesa was the place where the waggon halted the night previous to the oxen being taken to the sucking pits at Maralilen. Mr. Wilkinson himself did not recognise it, but if it were so, it is clear that Maralilen cannot be north of Kesa, or they would have come to it first. Mr. Wilkinson therefore places Maralilen on the same latitude as Kesa. The geological features and some topographical details along the course of the Molopo are from a map by Mr. W. H. Penning, F.R.S.

THE SANDGATE LANDSLIP.

By W. TOPLEY, F.R.S.

THE sea-front of the coast near Folkestone, Hythe, and Sandgate has long been known for its tendency to slip, and numerous examples of landslips, small and large, are there to be seen. In all these cases the cause of the slip is the geological structure of the ground, the strata consisting of alternations of pervious and of more or less impervious beds. At Eastwear Bay, between Folkestone and Dover, there is a huge tumbled mass of chalk, known as "The Warren," which has slipped over the impervious gault clay. As we proceed from east to west along the shore lower strata occupy the surface. Folkestone is mainly built on the highest division of the lower greensand—sands, sandstone, and hard calcareous bands, known as the Folkestone beds; these underlie the gault, and they overlie a set of clays and sandy clays known as the Sandgate beds. Where the latter beds crop out the old landslips begin, and they continue westward along the shore.* The town of Sandgate is built on an old landslip of the Sandgate beds, and the recent slip is only a small movement in the old slip. West of Sandgate the Hythe beds rise from beneath the Sandgate beds. These are bands of limestone and calcareous sandstone; they rest on Atherfield clay. The Atherfield clay, along its whole length for many miles to the west, has slipped more or less over the weald clay which underlies it, often bringing down masses of the overlying Hythe beds.

Three miles to the west of Hythe are the remains of Studfall Castle,

* Accounts of a landslip between Folkestone and Sandgate, which forced up the rocks along the shore, are given in the *Phil. Trans.* for 1716, p. 469, and for 1786, p. 220.

a Roman fortress built on the slope of the hill on Atherfield clay. This castle was destroyed by a landslip which probably occurred before the Norman Conquest. In *The Gentleman's Magazine* for 1756 (vol. xxvi, p. 160) there is an account of a landslip which occurred near this place in 1725. The slip occurred during a very wet season. A farmhouse sild down about 50 feet during the night, so gently that, it is said, the people inside were not aware of what had happened until in the morning they were unable to open the door. A similar gentle movement of the ground is apparent at Sandgate, where, during the recent slip, a greenhouse was wrecked, but it fell so slowly that most of the glass was unbroken. Slips frequently occur along the Atherfield clay near Hythe. Small movements of this kind occurred at the same time as the recent Sandgate landslip.

Behind the town of Sandgate there is a high cliff of Folkestone beds, below which come the Sandgate beds. At the western part of the town there are the Hythe beds, which also appear as rocks on the shore in front of the town. The dip of the strata is towards the north-east; the normal dip is gentle, but high dips are sometimes seen which may be due to slips. A deep cutting for a sewer is now open on the slope near the centre of the town. The effects of the old landslips are evident here, for below sandy clay of the Sandgate beds there are masses of peaty stuff containing recent plants. This old landslip must have been far more extensive than now appears, for its seaward front had been worn back by the waves before the town was built.

Special local causes may possibly have some influence in determining the exact position and origin of any landslip along this coast; but the main cause is always the same—the saturation of the land by heavy rains. The nearest rain-gauge to Sandgate is that at Hythe, where observations have been taken for many years by Mr. H. B. Mackeson, F.G.S. The average rainfall for February at Hythe, during the ten years 1883–1892, was 1·95 inch, with 13·8 wet days. This year the fall was 4·3 inches, twenty-four out of the twenty-eight days being wet; 1·06 inch fell on one day (February 21st).*

The Sandgate beds, in their undisturbed state, are only moderately retentive of moisture, from the large amount of clay which they contain; but when in a slipped and broken condition, as at Sandgate, they can contain a great deal of water. The recent excessive rains saturated the ground, and rendered the whole mass unstable.

The recent slip took place along an area 2775 feet in length, with a maximum breadth of 700 feet, measured from the back of the Encombe grounds to high-water mark. The foreshore was also moved for a breadth

* In Symon's *Monthly Meteorological Magazine* for March there is an account of "The Sandgate Disaster," giving details of the February rainfall in East Kent, the fall varying in six stations from 3·06 to 4·30, that at Hythe being the largest.

of perhaps 300 feet, making about 1000 feet in all. The extreme eastern limit is at the eastern end of the coastguard station; the western limit is just opposite the centre of the Military Hospital. The greatest vertical movement seems to have been about 10 feet—this is in the Encombe grounds; the horizontal movement of the slip is also small. The maximum effects are to be seen in various places in and near the Encombe grounds; fortunately, there are few buildings here.

The rocks on the shore were slightly moved, a bed of clay being ridged up about 4 feet. This movement of the rocky Hythe beds, and of the clay lying near, was probably due entirely to pressure from the moving mass of Sandgate beds.

As a "landslip" the movement is a comparatively small affair, and would have attracted but little attention were it not for the damage to houses; this, unfortunately, is large. No dwelling-house actually fell, but many are so much injured that they must be taken down.

The prevention of future slips is a simple matter, though necessarily a costly one for so small a place. Deep drains must be carried along the back of the undercliff, to carry off the water percolating from the Folkestone beds above; the undercliff must also be thoroughly drained, and no surface-water, other than that due to the rainfall on the area itself, must be allowed to enter the ground. This is the plan recommended to the local board by Mr. Baldwin Latham.

Much has been said about the probable effects of blowing up two wrecks off the shore—the *Calypso* in June 1891, and the *Benvenue* between September and December 1892. But any effect due to the former should have been felt long ago. The vibrations caused by the *Benvenue* explosions seem to have been no greater on the shore than those made by heavy storms at spring tides; but they of course shook the land behind more than such storms do. It is impossible to say that these explosions had no effect in rendering the land more unstable; but sufficient other causes for the landslip are apparent, and similar though smaller slips occurred along the coast in other places where these explosions could have had no influence whatever.

Another cause which may have partially assisted is the want of shingle on the foreshore. A sea-wall with groynes has been built on the east of Hythe; this largely stopped the eastward movement of shingle, and the sea-front of Sandgate suffered. New groynes have, however, now been built here and the shingle is again accumulating. If the want of shingle were the real cause of the slip its effect ought to have been felt some time back in wet weather. The want of support to the foreshore may possibly have had some effect in determining the exact time of the slip, when the ground became fully saturated, for the first important slip occurred at 7 p.m. on Saturday, March 4th, at low spring tides; the ground moved slightly during the night, and a second slip took place at low tide the next morning.