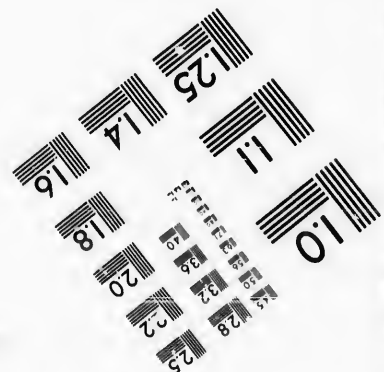
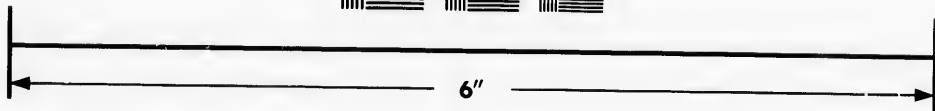
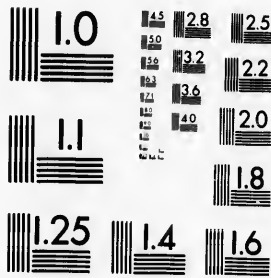


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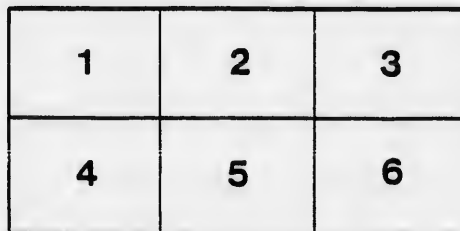
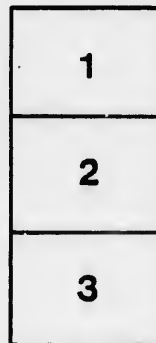
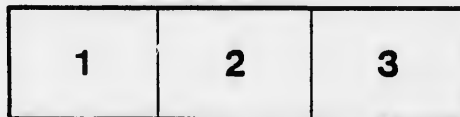
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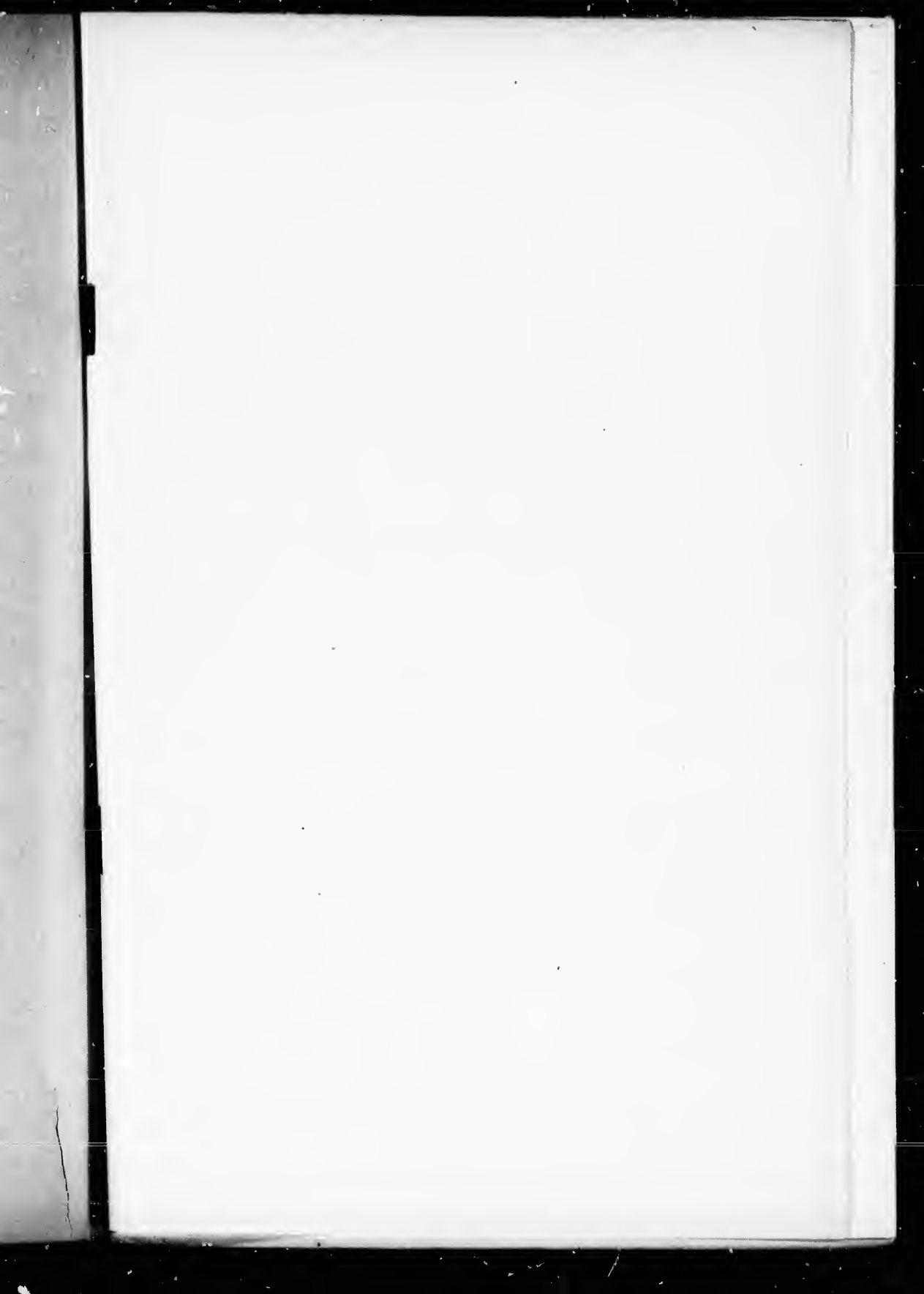
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REMARKABLE LANDSLIP IN PORTNEUF COUNTY, QUEBEC

BY GEORGE M. DAWSON

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LOCALITY AND CONSEQUENCES OF THE LANDSLIP

On May 7, 1898, a landslip occurred on the Rivière Blanche, a tributary of the Sainte Anne de la Pêrade, parish of Saint Thuribe, Portneuf county, Quebec. The



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FIGURE 1.—CLAY CLIFFS AT EASTERN END OF LANDSLIP AREA



FIGURE 2.—BLANCHE VALLEY OPPOSITE LANDSLIP, WITH LANDSLIP OUTLET IN DISTANCE

RIVIÈRE BLANCHE LANDSLIP

slip took place on the east side of the river, at a distance of 3 miles from the village of Saint Casimir. The results were disastrous to the farmers whose property was affected, one life was lost, two inhabited houses, a school-house, two barns, and several outbuildings were destroyed or engulfed, and cattle, horses, and other live stock perished.

#### EXAMINATION MADE

On May 29 I visited and examined the locality, taking some photographs of the scene, and a few days later, at my request, Mr R. Chalmers, of the Geological Survey, accompanied by Mr J. Keele, made a closer study of the circumstances as well as an approximate survey of the place, and procured additional photographs. The following brief description is based partly on my own observations, in part on those of Mr Chalmers, and is intended merely to outline the chief facts of interest, from a geological standpoint, respecting a mode of denudation that appears to have been not uncommon in the clay-floored plain of some parts of the Saint Lawrence valley.

#### CHARACTER OF THE COUNTRY

At the place in question, the Rivière Blanche, a small stream, occupies a valley running from north to south, about 1,000 feet wide, between sloping banks, 25 to 35 feet high, and nearly uniform in this respect. The surface of the country in the vicinity is for the most part under tillage, and is practically level to the eye, being a terrace-flat or plain composed of the marine Pleistocene deposit known as Leda clay, the whole thickness of which is not here anywhere shown. The clay is occasionally covered by arenaceous deposits a few feet thick and referable to the Saxicava sands.

To the north of and adjoining the wide crater-like depression produced by the landslip here particularly described there is, however, an irregular depressed area of nearly the same size, now under tillage, that evidently represents the site of a much earlier slip of the same character. Still farther to the north, and at a distance of 50 chains from the recent slip, the road, which runs parallel to the river valley and near it, crosses a low ridge of boulder clay. This material may be presumed to underlie the Leda clay elsewhere, but the subjacent rock is nowhere seen in the vicinity.

#### MODE AND EXTENT OF THE MOVEMENT

A small runnel of water appears to have entered the Blanche valley at the point where the material of the landslip subsequently found issue, and I was informed that previous to the main slip a small slide had been noted to occur at this spot. At half past five in the morning the inhabitants were alarmed by the movement of the soil, which then suddenly began and continued for three or four hours. The immediate bank of the river valley appears in the first place to have given way along a front of about 200 feet in width, and the gap thus made rapidly extended inland, forming an opening through which a great body of clay behind rushed tumultuously out into the Blanche valley. At a short distance from the bank of the valley the width of the area affected greatly enlarged, the sides of the depression collapsing and falling into the gulf, until a crater-like hollow of bottle-shaped outline and opening on the valley by a narrow neck was produced.

The inhabitants on the spot were so much alarmed that they naturally did not observe the actual progress of the landslip with great precision, but eye-witnesses describe the passage of blocks and pyramids of clay through the orifice to the river valley as being very swift and resembling steamers in motion on a river. The occurrence, in fact, may be said to have resembled the bursting out into the valley of a lake of liquid mud, bearing with it outstanding and unbroken blocks of clay detached from the sides of the collapsing area.

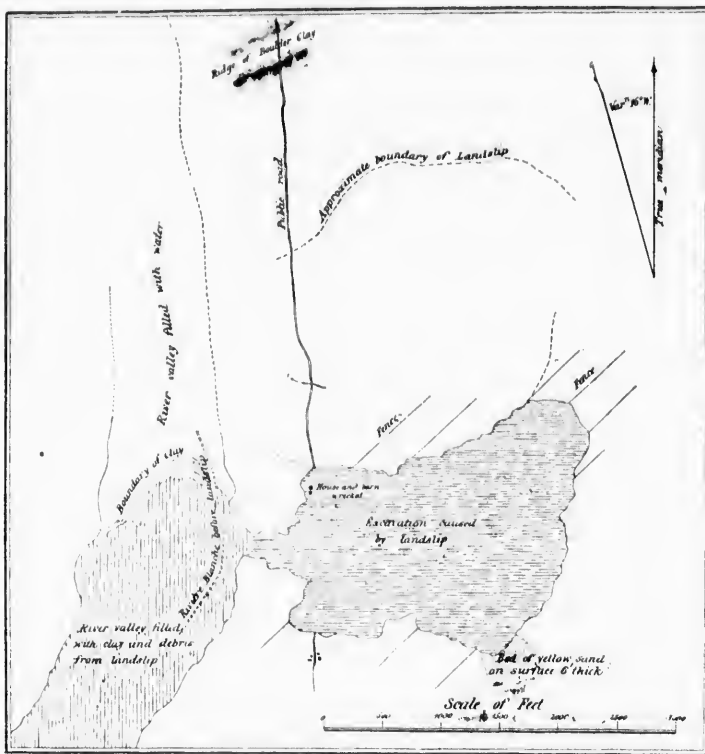


FIGURE 1.—Sketch-plan showing Area of Landslip (horizontal lining), Part of Clay-filled River-valley (vertical lining), and approximate Boundary of an ancient Landslip of the same Kind

On entering the Blanche valley the flood of clay spread upstream for some 500 or 600 feet, ponding back the river water, but the greater part, descending the valley for nearly two miles, filled it for that distance to a maximum depth of fully 25 feet, causing the destruction of the rich meadows along the valley, besides that of the agricultural lands immediately affected by the collapse.

When examined by me, the actual landslip was represented by a depressed area bordered by clay cliffs from 15 to 30 feet high, 1,700 feet in maximum width, with a

greatest length of 3,000 feet and an area of 86 acres. The floor of this depression was formed by irregular mounds, pyramids, and blocks of clay, with trees, portions of fences, and other debris and small pools of water here and there; although it is stated that very little water was seen during the actual movement of the mass. The wrecks of trees coming from a wood-lot, part of which still remains near the head of the crater, showed very clearly the direction of flow of the mass. The channel of the Blanche below the orifice of the slip was entirely filled, and the water spread from bank to bank of the valley amid mounds and blocks of clay and debris that stood above it.

#### AMOUNT OF MATERIAL INVOLVED

The quantity of material which thus poured suddenly out into the Blanche valley is approximately estimated at 93,654,000 cubic feet, with a total weight, according to the specific gravity determined, of about 5,572,413 tons of 2,000 pounds.

The slope of the original surface from the head of the collapsed area to the point at which the road formerly passed, near the entrance to the narrow outlet, was, according to barometric observations by Mr Chalmers, about 10 feet only. The approximate difference between the average level of the bottom from the head to the present water level in the Blanche valley, according to the same authority, is between 20 and 25 feet, while the slope of that part of the Blanche valley from the orifice of the slip to the extremity of the flood of clay is not much more than 30 feet.

#### EXPLANATION OF THE CATASTROPHE

The light slopes indicated by the above figures show that the mass of clay must have simulated a liquid body when in motion. Mr Chalmers suggests that a lower bed of the clay, in consequence of the impermeability of the subjacent boulder clay, became exceptionally saturated, forming a sliding plane upon which the more coherent overlying masses moved down. This would be in conformity with the explanation usually (and probably in most cases correctly) given for landslips, and it seems very likely that something of the kind may have been concerned in the initiation of the slip here described where it began on the bank of the Blanche valley. It appears to me, however, that the great and sudden discharge of clay in this case should rather be attributed to the character of the water-saturated mass as a whole, particularly as no evidence was found of any specially permeable or fluent bed and no underlying surface either of boulder clay or rock is anywhere exposed. It will be noted that this landslip differs very markedly in character from the ordinary form, in which the subsidence occurs along an extended front.

Three representative specimens of the clay, collected by Mr Chalmers while still in a nearly saturated condition were submitted to a careful examination in the laboratory of the Survey under Doctor Hoffmann's supervision. A mean of the results obtained shows the specific gravity of the clay as received to have been 1.912, equivalent to a weight of 119.5 pounds to the cubic foot. The clay as received was found capable of absorbing a small additional amount of water, varying from 7.0 to 0.2 per cent by weight. Apart from the water, it consisted of 35.5 per cent of argillaceous matter and 43.3 per cent of silt. When fully saturated it contained on the average, which varied little in the three samples, 23.5 per cent of water by weight or nearly 50 per cent by volume.

It will be noted that the Leda clay here contains a considerable proportion of silt as compared with the argillaceous matter proper, bearing out an observation made to the same effect on inspection of the locality. The large amount of silty matter present would render the clay unusually permeable, and it seems, therefore, to be probable that the water saturated the mass by descending directly through it from the surface, in a manner which would not have been possible in the case of the more purely argillaceous clays of the same age usually found.

In Rankine's Civil Engineering it is stated that "the presence of moisture in earth to an extent just sufficient to expel air from its crevices seems to increase its coefficient of friction slightly; but any additional moisture acts like an unguent in diminishing friction and tends to reduce the earth to a semifluid condition, or to the state of mud." It appears probable that in this particular instance the silty clay, surcharged with water, stood in a condition of unstable equilibrium, retaining its solidity merely by virtue of its unbroken molecular texture, and that at the moment in which it became subject to internal movement this texture gave way and it lapsed into a nearly liquid mass, the particles rearranging themselves with some freedom in the water previously locked up in its pores.

The fact that many clays when once completely dried and then immersed in water lose their plastic character and crumble down into an incoherent mud, shows that the natural texture is an important element in their coherence and plasticity, and one which does not appear to have been fully recognized in connection with experiments on clays and soils.

The high specific gravity of the fluent portion of the mass in this case, no doubt enabled it to carry the unbroken blocks of clay along that were supplied by the collapsing sides of the crater-like depression which was immediately formed, and when not subjected to stress these blocks continued to retain their original firmness and form.

The fact that the great mass of moving material was discharged through a comparatively narrow orifice, shows that the bank of the valley through which it passed was much firmer in character than the clay forming the subsoil of the plain behind. This no doubt arose from the natural drainage of the clay along the bank preventing its complete saturation. The same explanation no doubt accounts for the northern limit of the collapsed area occurring along the line where the surface begins to slope down toward the hollow of the old landslide already mentioned, but the limiting causes on the east and south are not clearly apparent.

Inquiries made on the spot showed that no excessive rains had occurred immediately preceding the slip, but that a great depth of snow lay upon the ground during the latter part of the preceding winter. These statements are confirmed by the meteorological observations made at Quebec, about 40 miles distant, which have been obligingly furnished by Mr R. F. Stupart, director of the meteorological service. From these it appears that the total precipitation (in rain or melted snow) for the months of November and December, 1897, and in January, March, and April, 1898, was slightly below the normal for the past 24 years, but that in February, 1898, it was two inches above the average, in the form of an abnormal excess of snowfall in that month of 17.9 inches, the total snowfall for February, being 44.2 inches. The ground was thus heavily burdened with snow in the later winter. During April most of this melted and the soil itself thawed, permitting



FIGURE 1.—NORTH EDGE OF LANDSLIP AREA, VIEWED EASTWARD FROM NEAR THE OUTLET



FIGURE 2.—OUTLET OF LANDSLIP, LOOKING TOWARD BLANCHE VALLEY

RIVIÈRE BLANCHE LANDSLIP

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the absorption of the water and resulting, early in May, when the clay beds had thus become thoroughly saturated, in the landslip which has been described.

#### PROTECTION FROM SIMILAR DISASTERS

The only way in which the recurrence of such slips in regions of country of the same character and under similar exceptional conditions of precipitation can be guarded against appears to be the provision of effective surface drainage, such as to carry off the excess of water before the rather slow process of absorption by the subjacent clays can take place.

#### SIMILAR OCCURRENCES IN THE SAME REGION

In a paper entitled "*L'Eboulis de Saint Alban*,"\* Monseigneur Laflamme has given an excellent account of a landslip that occurred on April 27, 1894, on the Sainte Anne river, distant about 7 miles only from that above described and affecting similar deposits of the same plain, although at Saint Alban a large part of the slide consisted of the Saxicava sands, there developed in great thickness above the Leclay clay.

The landslip at Saint Alban was also much larger than that on the Blanche, an area more than 3 miles in length along the river and about 7,700 feet in greatest width having moved bodily down into the valley. Five or six farm-houses were destroyed or swallowed up, four lives were lost, and the entire mass of the slide is estimated at from 600,000,000 to 700,000,000 cubic feet.

The landslip at Saint Alban was also different in its cause and character. The river was first dammed by a comparatively small slide, and when the water thus held back eventually broke through, its undermining action on the high banks of the valley was such as to precipitate the collapse of the much greater area above noted.†

A brief description of a landslip almost identical in character with that of the Blanche and affecting a similarly situated part of the same Saint Lawrence plain has, however, previously been given by Sir William Logan in a paper read before the Geological Society of London in 1842.‡

This landslip occurred on the Maskinongé river, about 50 miles to the southwest of the Rivière Blanche, on April 4, 1840, and was examined by Logan in the following autumn. Like that on the Blanche, its outlet through the bank of the valley was narrow, and its greatest width, about 600 yards, occurred at some distance back from this bank. The length of the collapsed area was 1,300 yards, and its area about 84 acres, the depth of the depression being about 30 feet. The nearly liquid clay flowed both up and down the valley of the Maskinongé for a distance of about three-quarters of a mile in each direction, bearing with it large blocks and masses of unbroken clay. The whole movement was effected in about 3 hours, the first mass of clay detached being about 200 yards in width by 700 in length.

\* Transactions Royal Society of Canada, vol. xii, part iv, 1891, p. 63.

† Since the present paper was read a short note by the same author on the Blanche landslip has been published in the Report of the Commissioner of Colonization and Mines of Quebec for 1898, p. 131.

‡ Proceedings of the Geological Society of London, vol. iii, p. 767; also Life of Sir William Logan, p. 95.

Logan particularly notes that, except on one side, the area of the terrace-flat affected by the slip was bounded by lower land, a ridge or crest being left between the collapsed area and this lower land. This is quite similar to the fact observed in connection with the landslide on the Blanche, and is, no doubt, to be explained in the manner previously alluded to. He nowhere saw the underlying rock or other material below the clay, but is inclined to the belief that the movement may have occurred on a sloping bed of rock. If, however, my interpretation of the facts on the Blanche be correct, it seems unnecessary to assume the existence of such a sliding surface in either case, the action of gravitation upon the saturated mass of clay itself being probably sufficient to account for its flow to the lower level, the retaining bank having been broken through in the first instance.

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