Translation No. 7

# LANDSLIDE IN MOUTIER-COURT GORGES
(A translation)

Peter, A. (Chief Engineer at Delemont), Glissement de terrain dans les gorges de Moutier-Court; La Route et la Circulation Routiere, no. 10, pp. 165-172, 206-208, 23 fig., Solothurn, Switzerland, 1938.

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Translated by Mrs. Severine Britt, U. S. Geological Survey, 1947.

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The road that leads from Bale to Bienne, across the Bernese Jura, goes through the very picturesque gorges located downstream and upstream from the industrial village of Moutier. The Birse stream carved its way through the Raimeux and Graitery ranges, cutting them perpendicularly in a south to north direction.

The local road which crosses these gorges generally follows the stream and is in places in contact with unstable marly formations. Thus in the gorges upstream from Moutier, between Moutier and Court, the road is affected by tectonic movements and has already been destroyed many times or covered with rock waste.

In these gorges the Birse cuts the anticline which constitutes the Graitery range at right angles, according to the geologist, Dr. Buxdorf; the axis of the anticline trends west and the eastern side of the valley exposes the oldest formations. The central part of the Moutier-Court Gorges is occupied by the following Jurassic formations (figs. 1,2, and 3):

1) Oolitic limestone (Hauptrogenstein), 120 m. thick, can not be seen in the gorges but this formation was encountered in the tunnel of Moutier-Granges..

2) Callovian: marly limestone (iron oxide) of a thickness of 30-35 m. These rocks crop out only at one spot on the south side of the Graitery anticline.

3) Oxfordian: marly-argillaceous formation, 60-70 m. thick, bluish marl. Flint nodules or calcareous concretions are found in the lower part of this marl. It will be noted that the presence of this Oxfordian marl very readily causes landslides.

4) The Argovian: overlying the Oxfordian gray argillaceous layers, includes two distinct beds: (a) the lower Argovian, strictly calcareous, 35 m. thick; (b) the upper Argovian, of marly character. The Argovian layers are easily visible as they form the lower part of the eastern side of the gorges. It will be seen later that the Argovian terrain forms an important part of the material of the landslide which occurred in the gorges in 1937.

5) The Sequanian succeeds the marl of the upper Argovian; it is mostly calcareous and constitutes the middle portion of the rock walls of the gorges.

6) The Kimmeridgian forms the high walls at the end of the Gorges of Court, downstream as well as upstream.

The strata just enumerated form an arch in the central section of the gorges. This arch, however, is not symmetrical: its south side is slightly inclined whereas its north side is vertical. In addition, an overthrust occurred in the layers of the north side; this overthrust is perfectly visible in the Argovian layers. The geologists' opinion varies as to whether this overthrust extends as far as the core of the anticline.

Rock waste in the central section of Court Gorges

The considerable extent of sliderock and the flows of Oxfordian marl mixed with debris which are found in the central section of the Court Gorges make the outcrops of rock stand as small islands. The mantle of debris is particularly important in the region of the anticline core. Here a large part of the underlying material is formed by the argillaceous Oxfordian, which is very conducive to landslides. This cover of rock waste not only extends on the sides of the valley but also constitutes the bed of the Birse stream. Nowhere in its course in the central part of the Court Gorges does the Birse run on rock; the river runs on mountain waste only, which comes down from both sides and mixes with the alluvium brought down by the stream.

The geologic structure of the central part of the Court Gorges, with the presence of very abundant Oxfordian marl at the anticline core covered by an important layer of debris, makes this part of the gorges very inviting to landslides. Thus an important landslide occurred at the end of March and the beginning of April 1937.

Landslide in Court Gorges (fig. 4)

In March-April 1937, one of the most important landslides known in Switzerland occurred in the central section of the Court Gorges, on the eastern side. This landslide was important on account of the extent and the volume of the mass which was set in movement, and because of the destruction of the railroad and the road which connect North Jura to South Jura. In addition, this landslide caused serious trouble to the commune of Moutier by destroying the pipe line supplying the factory at the entrance of the gorges, and a forest of an area of about 10 hectares (figs. 5, 6 and 7).

The first signs of an earth movement in this section of the gorges were noticed in the morning of March 27 by the engineer of a down-train; the strong shock felt when the engine ran over a certain spot indicated that the track had been displaced. A second evidence appeared on March 28: it was the rupture of the pipe line, 80 cm. in diameter, which was set in the road. Soon afterwards, slight displacements of the railroad and the road occurred. These displacements became more and more evident by their extent, and their movement kept accelerating. On the 29th, the retaining walls, upstream and downstream from the road, broke and the road started to heave, which rendered traffic difficult. Another sign was the disappearance of all the abundant springs which spouted out in the area affected by the slide. The railroad traffic was maintained until the 31st of March by successive realignment of the track; from then on it was necessary to stop the traffic. The events were then precipitated and on April 2d the road traffic also had to be stopped. The development of the successive stages of the landslide occurred as follows (see also figs. 8, 9, 10, 11 and 12):

The extent of the area in question is, as said above, about 10 hectares; the moving mass of about 2,000,000 $m^3$, according to the estimate of the geologist, Dr. Buxdorf.

Two lobes formed at the lowest part of the landslide. The upstream lobe which advanced westward on a front of 80 m., in the direction of the Birse, carried the railroad and the road along, the road being simultaneously heaved. The bed of the Birse was overrun and the stream was forced out to the left. Its level rose considerably, about 6 m., forming a small lake upstream from this part of the landslide front. On the other hand, the downstream lobe evolved differently from the former; its movement was rather superficial. It ran over the rocky outcrops of the Argovian, covering the railroad track and the road, the latter being probably destroyed; upon entering the bed of the Birse it formed a dam 9 m. high and created a second lake upstream. These two lobes have quite different characters: the upstream lobe consists of a movement extending to depth; the downstream lobe, contrarily, constitutes the overflow of the main slide.

The total amount of the horizontal displacement of the ground was determined by a control line at the level of the lower third of the slide. The total displacement of some points on this line was 45 m. (max. 49.5 m.). It is likely that the movement was slower in the upper portion of the slide. In the lower portion, the total advance of the face of the upstream lobe was about 30 m.; the slide face in this section struck against the left bank of the Birse.

From these facts, Dr. Buxdorf drew the following conclusions:

1) The middle and low portion of the mass underwent a movement of translation varying between 30 and 50 meters.

2) In the upper portion of the slide, the movement was slower.

3) The scarps which were formed in the upper part of the slide, (separation zone CC', DD', fig. 4) are the result of a fracture caused by the fact that the lower portion of the mass flowed more rapidly on account of its great capacity of absorbing water rather than because of the inclination of its slide plane.

The mud creeps, the partial streams of rock waste, and the numerous fissures seen in the landslide area will not be emphasized, as they are secondary phenomena related to all landslides, whatever their type may be.

As regards the causes of the landslides, they were due to the abundant precipitation from January to March, which reached 3 to 3½ times the usual amount. On the other hand, the mean temperatures in January and February were from 2° to 4° higher than the normal temperature. The result was that the soil was abnormally saturated with water. Moreover, the upper portion of the moving ground was swampy and the steady rain water penetrated more deeply in this region than under normal atmospheric conditions. The ground mass impregnated with water was made heavier and became plastic. As a result, it exerted pressure on the lower earth masses and these started moving. A slide plane was formed at a certain depth and movement of the overlying loose ground followed. The slide concerns only the superficial part of the great mass of scree occupying the east side of the gorges, and according to Dr. Buxdorf, it is a typical talus creep. The area of the landslide is, as said previously, 10 hectares, the volume of the fallen mass 2,000,000 $m^3$, assuming the slide plane to be at a depth of 15 to 20 meters (fig. 13).

Are predictions on the duration of the movement difficult to determine?

The movement was especially important at the beginning of the slide, when the average displacement reached 1 m. and more per day, until about the middle of April. Then, it diminished rapidly, dropping to 1 to 2 cm. in June and July, and 0.001 m. for the period from Jan. 14 to 31.

From these observations, two conclusions are to be retained:

1) The movement decreased considerably after a very rapid advance. This means that the displaced masses resume little by little a new state of equilibrium.

2) In the present and even in the future, one should not count on a permanent stability of the moving masses.

There are many springs in the landslide area but their discharge is variable. They very quickly reflect the influence of rain and drought, as do all springs from superficial deposits. They are not fed from the interior of the Graitery chain, but instead the water penetrates the scree formation located between the north-east angle of the slide and the point "C" (fig. 4). In addition, the landslide receives the water which falls in cascades on the walls of the lower Argovian after gathering on the marl of the upper Argovian at the crest of the anticline of the Graitery chain.

The total discharge of all the springs which issue on the slide varied, according to observations made during the period June 1st to October 30th, between 133 liters/sec. (Sept. 11, 1937) and 0.1 liter/sec. (Oct. 30th). The most important spring is along the upper edge of the scarp made by the downstream lobe and has a flow varying between 4 and 1,800 liters/minute.

The Gorges of Court have had a succession of catastrophes and landslides. Letters kept in the archives refer to important landslides that "again took place" in the gorges, namely in May, 1770 and in March, 1844. The landslide of 1844, although considerable, was, however, not as important as those of 1770 and 1937, both of which affected the eastern side of the gorges; in 1844, the movement was more superficial and extended over an area of about 3.5 hectares. However, in the surroundings of the Birse and the road, similar phenomena were noted, namely a rise in the bed of the river and heaving of the road, phenomena due to the pressure of the moving mass against the opposite slope.

Measures taken after the landslide of 1937 to avoid an aggravation of the situation, to facilitate the outflow of the Birse stream and to reestablish the road and railroad traffic

In order to slow down or to stabilize moving ground, the first step is to remove the superficial and spring water which seeps into the mass. Therefore gangs of workmen were immediately occupied here, mostly in the upper part of the slide, with the construction of wooden culverts and with opening natural ditches to collect the water flowing on the landslide. This water was then drained off by means of two centrifugal pumps of 400 lit./min. each (figs. 14 and 15). The measures taken surely contributed to the slowing down of the slide for about the middle of April some stabilization of the frontal mass of the slide was already noted.

From the beginning of the slide, some anxiety arose as to the effects the obstruction of the Birse River might have for the village of Moutier, located a few km. downstream.

It was first attempted to keep open the bed of the Birse by means of strong wooden frames of 4 by 2.5 m., 30-40 cm. in diameter, but it was in vain; the pressures exerted by the face of the slide very quickly broke these frames. An excavator was then used but without success; the best measure, although expensive, was blasting. This prevented the water from rising in the two lakes formed by the masses of the slide face (figs. 16 and 17).

The problem of railroad and road traffic was solved as follows:

A temporary road was quickly built on the left bank of the Birse, using the course of a former Roman road, and a temporary wooden bridge was built upstream from the slide. The length of this road is 1,000 m., the width ranges between 4 and 5 m., and the maximum grades are from 10% to 11%.

The mass of rock waste which covers the bed of the Birse, the road, and the railroad, is about 100,000 $m^3$. The removal of the mass can not be considered in order to reestablish the former state of things without fear of throwing the fallen mass out of balance again. The construction of a new road on the slide must also be given up for it would be too expensive on account of the magnitude of the drainage and protection works required. Besides, one could not be sure that the new state of things would be maintained in the future. The history of this region shows that landslides occurred there at all times. Only one solution offers the greatest chance of security: it is the permanent establishment of the road on the left bank of the Birse where the dangers of landslides are less, and their effects of less consequence.

Concerning the railroad the problem is somewhat different. The railroad could be reestablished on its former track or detour around the slide through a tunnel which would be built either on the right bank or the left bank of the Birse. This last solution is also very expensive and offers technical difficulties. The railroad company has, therefore, resigned itself to take its chance and proceeded to the clearing of the former track.

The choice of these two solutions, the road on the left bank of the Birse and the railroad on the right bank, has the advantage that in case of new landslides coming either from the eastern or from the western side, one of the lines of communication will remain open and the traffic will be maintained between the upstream and downstream sections of the Birse valley. Even if landslides occurred simultaneously on both sides of the gorges, the road communication could rapidly be reestablished as the landslides on the left bank of the Birse will always have a local character owing to the geologic disposition of the strata.

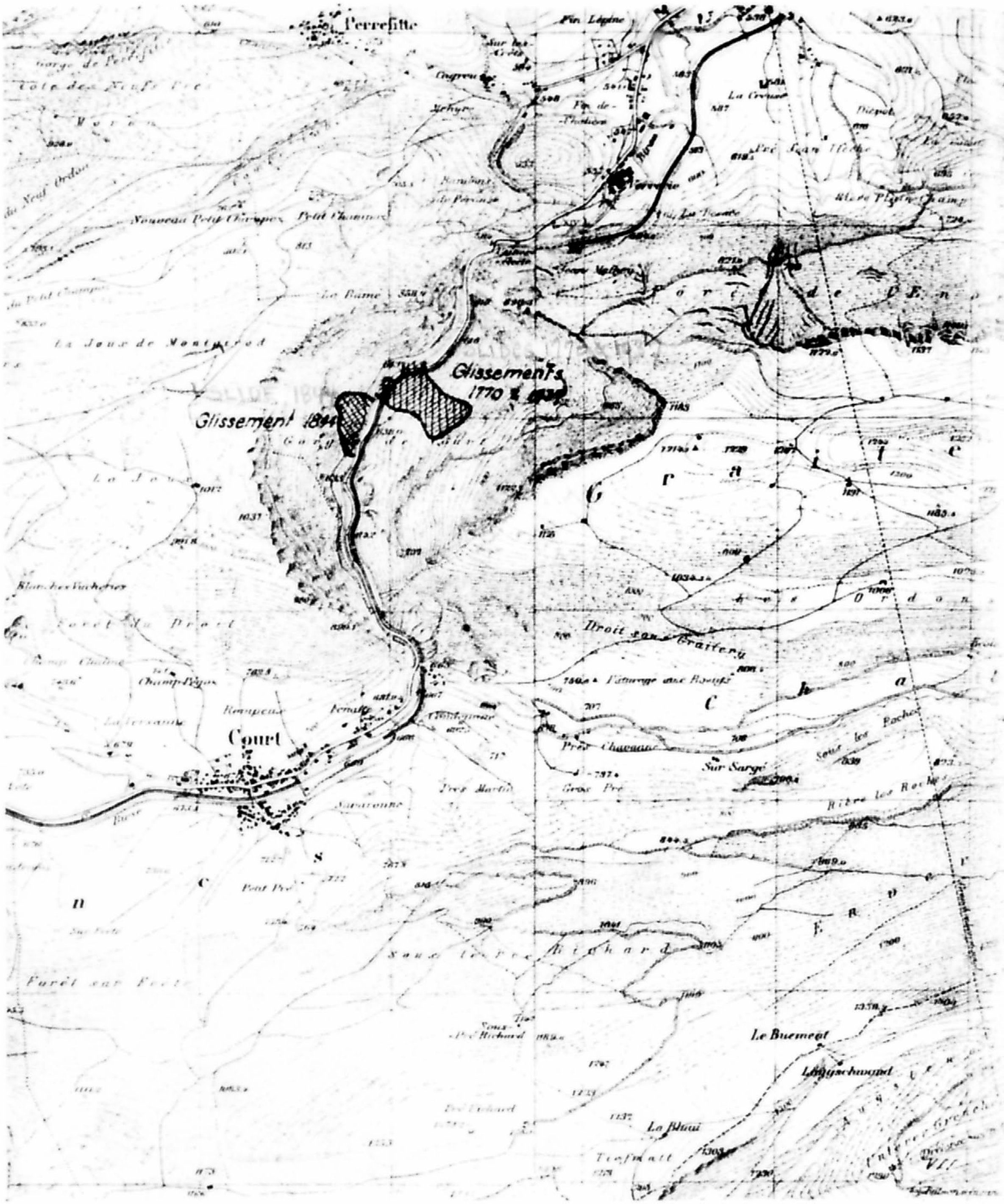



Fig. 1. Reproduit avec l'autorisation du Service topographique fédéral du 5 mai 1938.

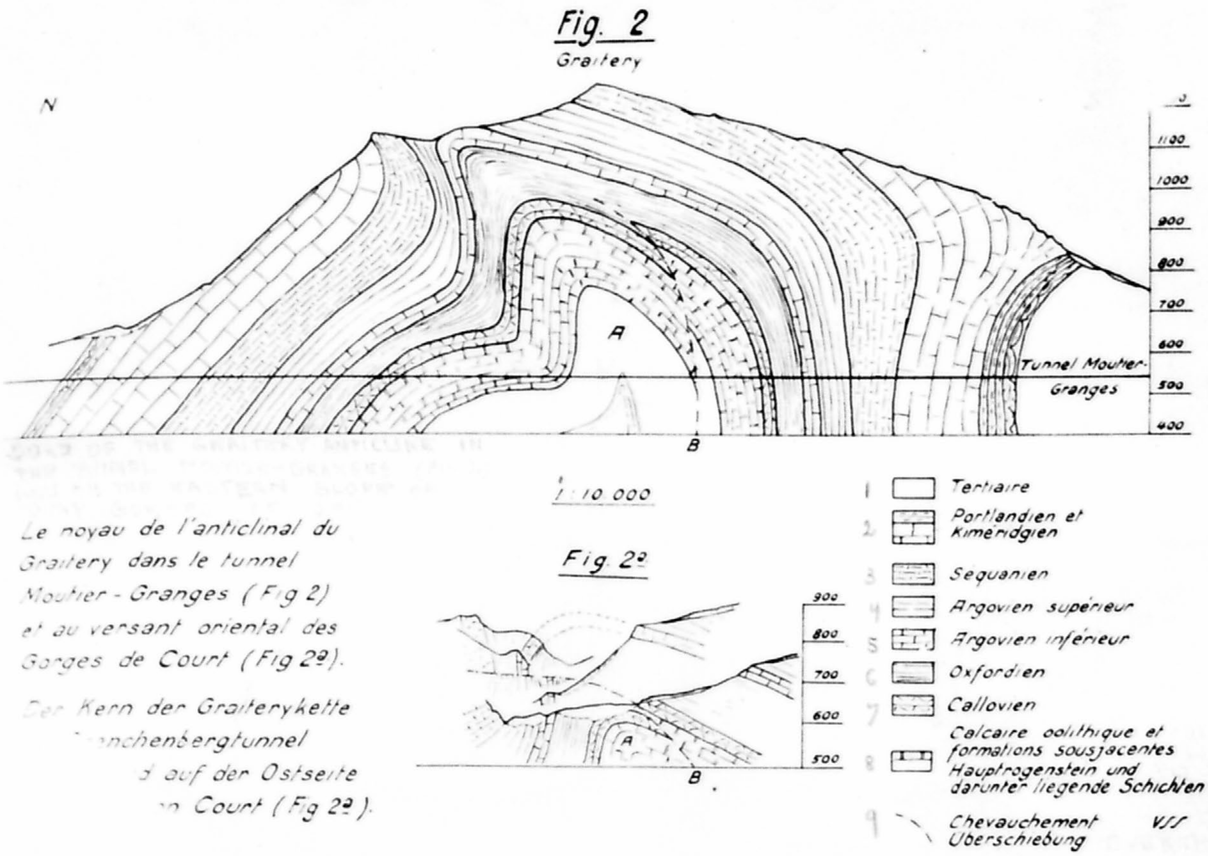
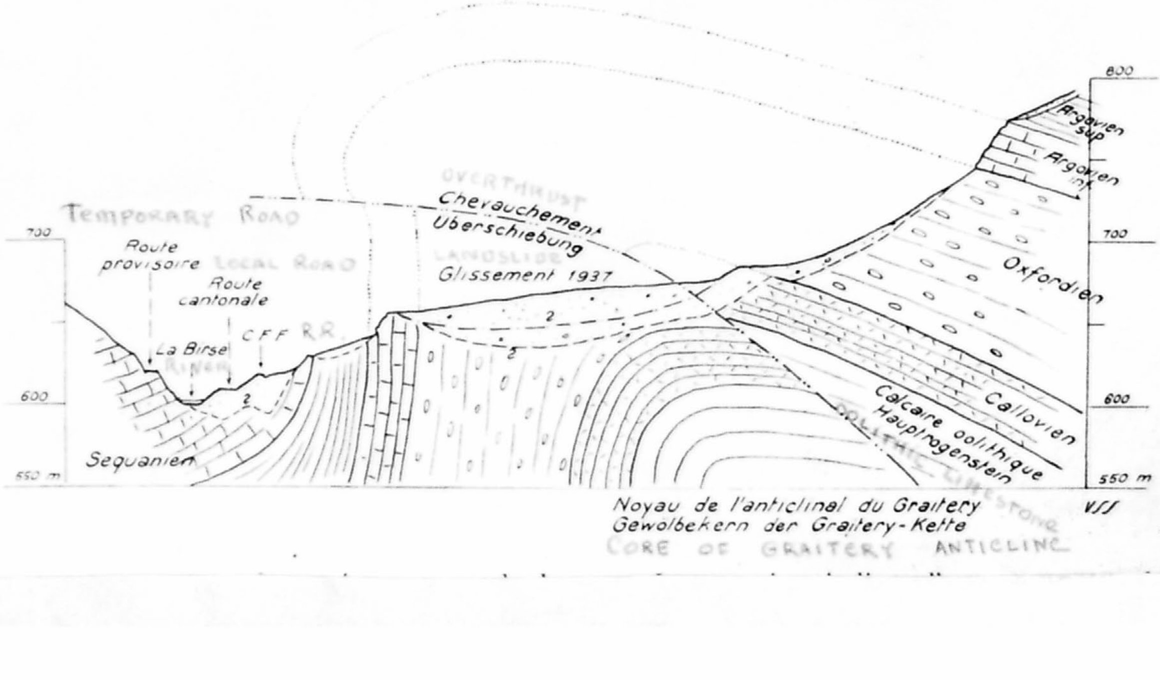



Fig. 3.

**Coupe géologique à travers la partie centrale des gorges de Court**

par Dr A. Buxtorf et Dr L. Vonderschmitt, géologues à Bâle.



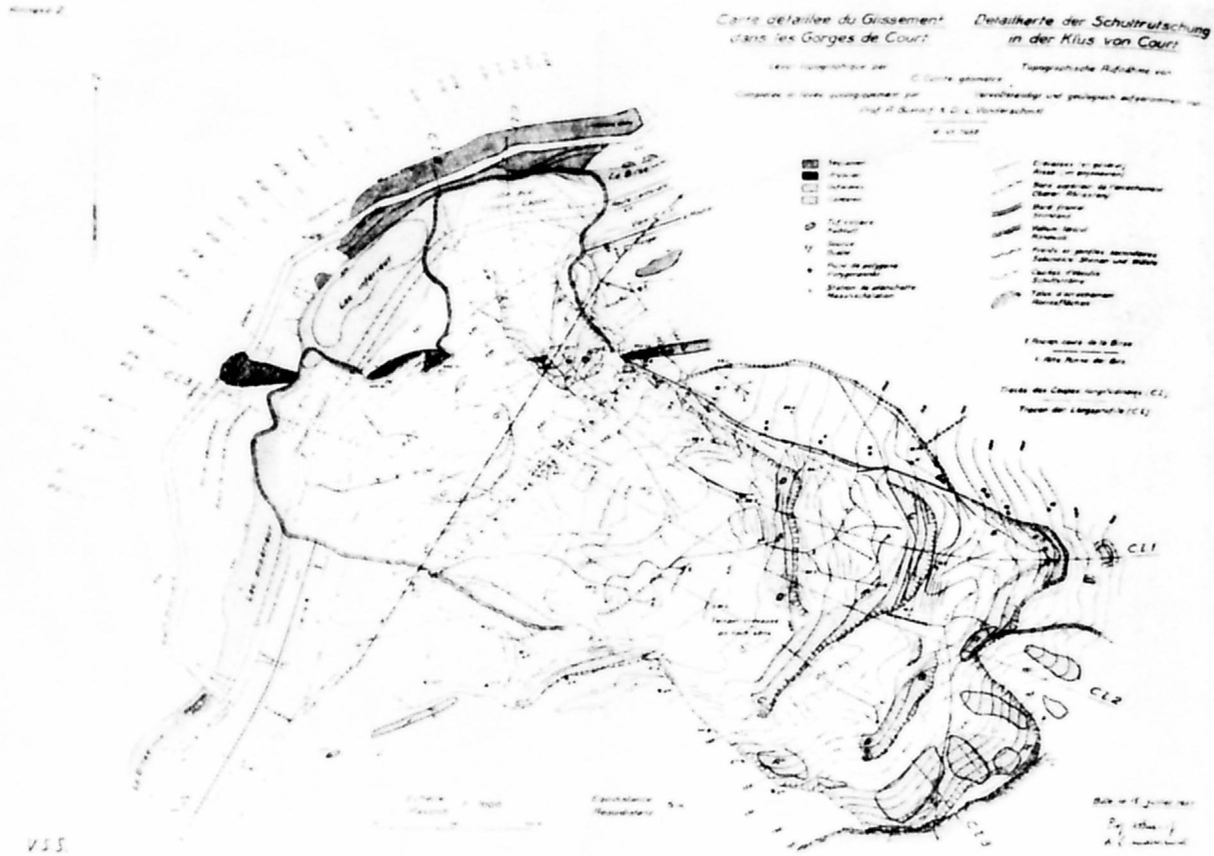



Fig. 4.

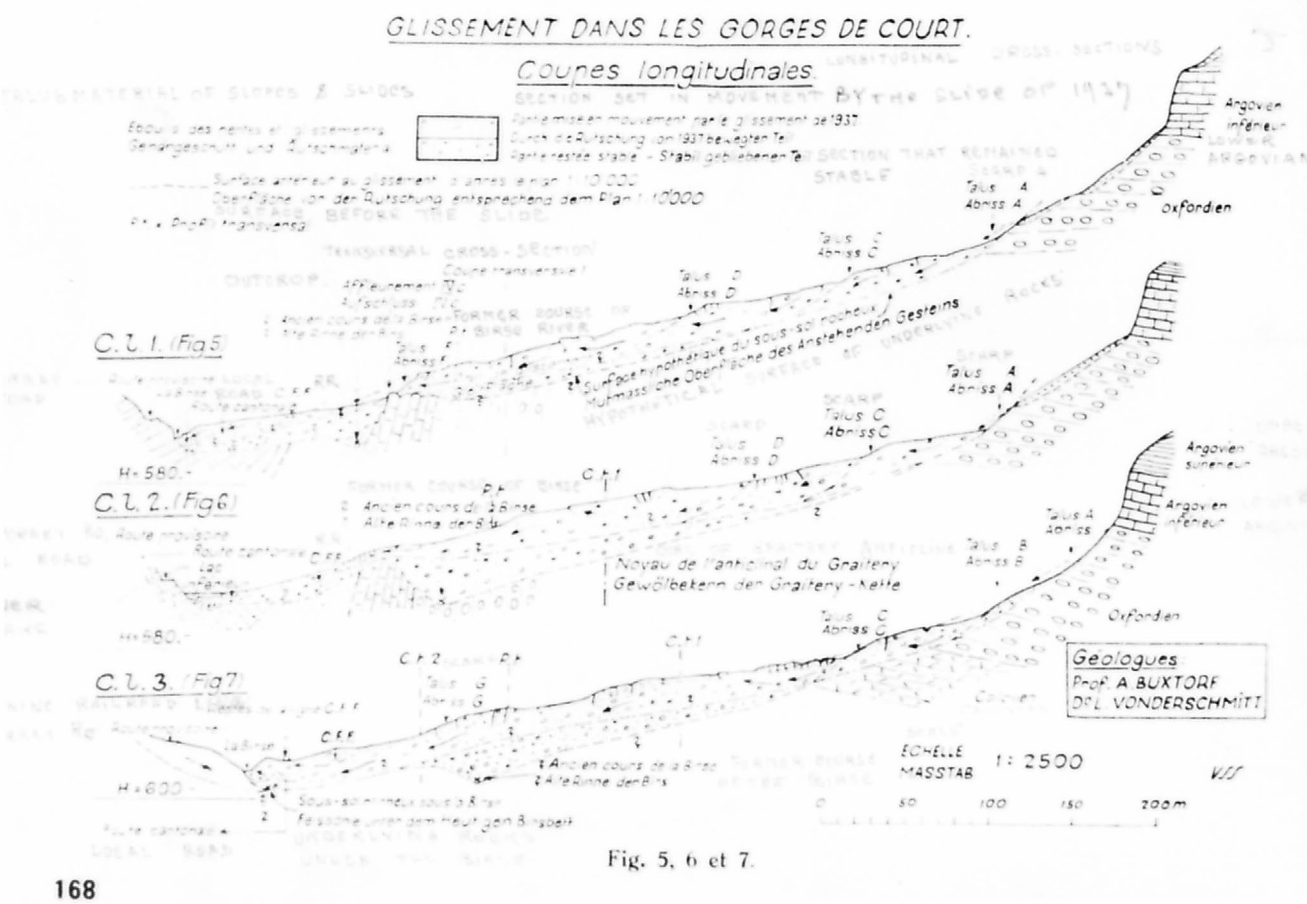



Fig. 5, 6 et 7.

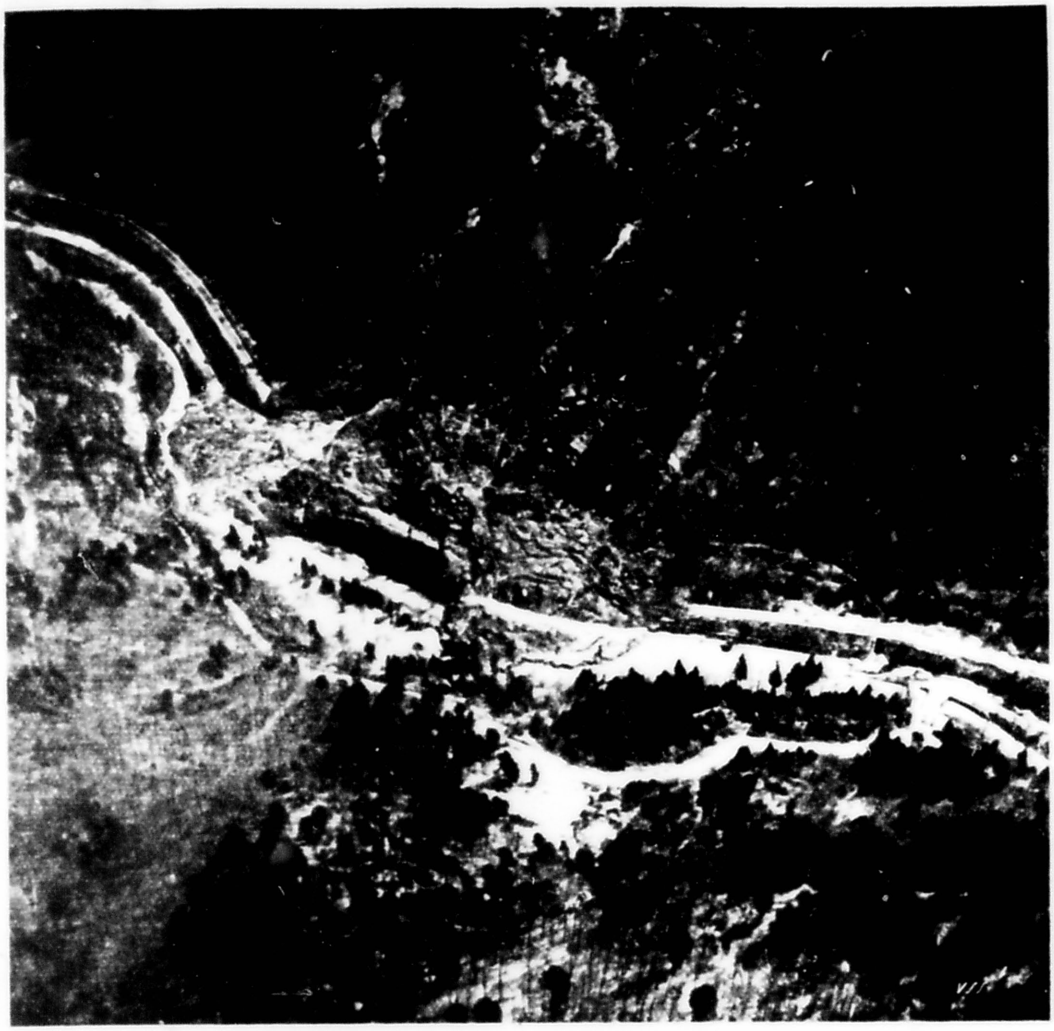


Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

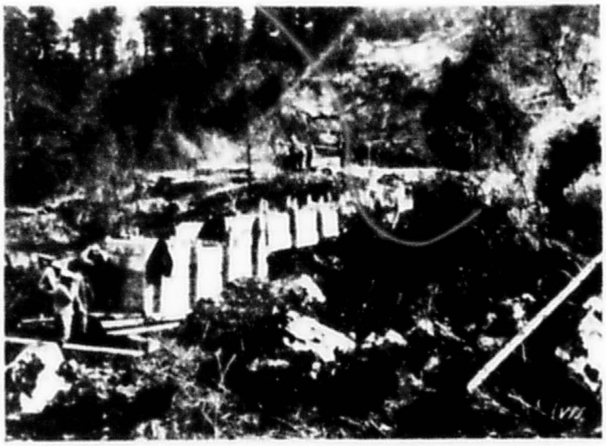


Fig. 14.

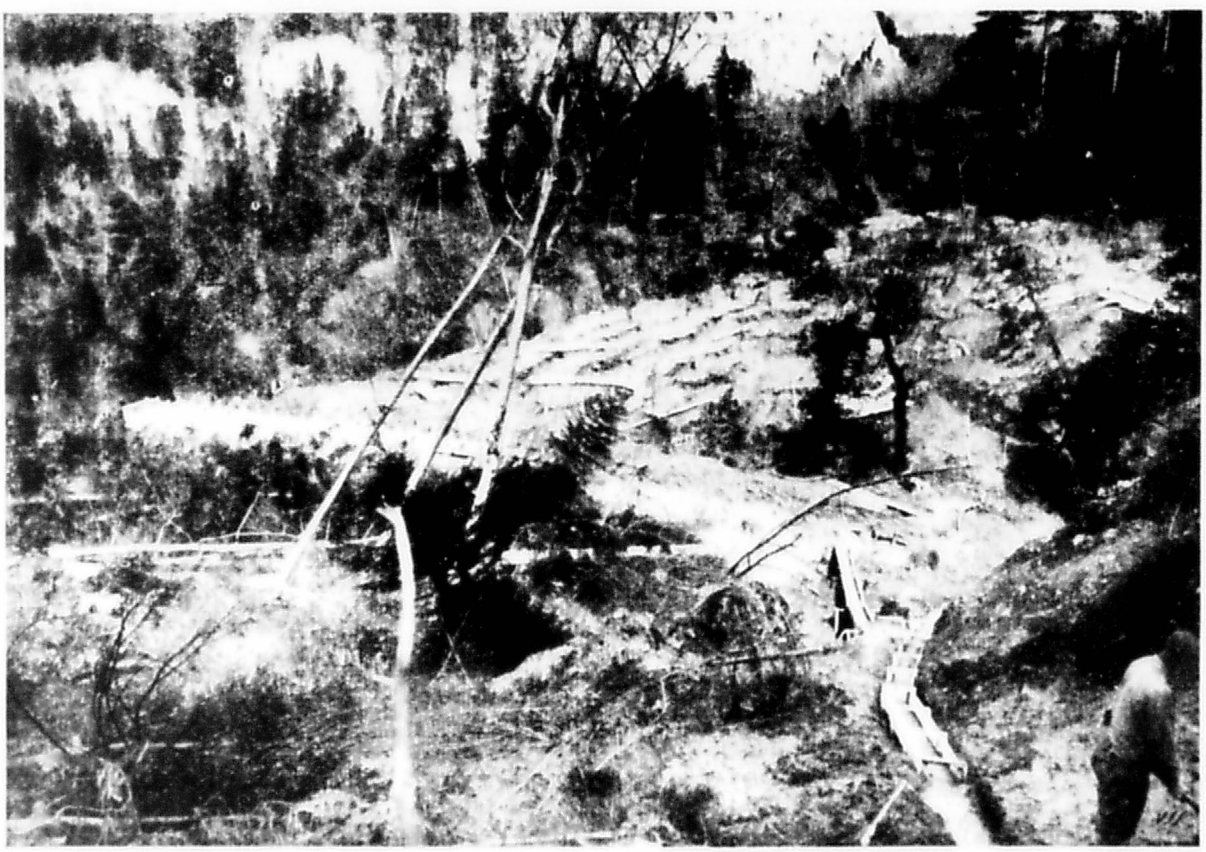


Fig. 15.


Fig. 16.


Fig. 17.

Fig. 18.

Fig. 19

Fig. 21.

Fig. 20.

Fig. 22.

Fig. 23.