LANDSLIDES STUDY IN VALLE VEDETTA, GIANICO (BS)

A cura di Paola Comella

paola.comella@mail.polimi.it

Indice

1 INTRODUCTION

The purpose of this study is to analyze the causes and dynamics of landslides affecting the Val Vedetta, which is a creek located in Gianico (BS) (Figure 1) in Valle Camonica; in 1960, after a month of abundant rainfall, a debris flow destroyed the historic center.

Figure 1 Ruins in Gianico after the flood of 1960

After this natural disaster, several studies (F. Villa, 1967; Idromin. Milano, 1967; F. Alberti, 2003; F. Alberti et al. 2003-2012) tried to understand the causes of the earth collapses also because along the river banks a number of minor movements often occurred.

2 STATE OF THE ART: GEOLOGICAL SURVEY AND SOLVING METHODOLOGY

From a geological point of view, Valle Vedetta bedrock is composed of “Micascisti del Maniva”, “Verrucano Lombardo” and “Servino”; the bedrock is covered by a large amount of glacial debris. A geomorphological survey (Figure 2) demonstrated that many long and deep arched trenches runs through the soil slope, penetrating in the crystalline bedrock. There is also a fault that crosses Vallone at an altitude of 700 meters. This fault damages crystalline rock by creating fractures in depth.

The debris is moving towards the Vedetta Valley, and the geological survey demonstrates that all the slope is affected by wide deep-seated landslides of the crystalline rock. The size of the landslides is about 100.000 m^3.

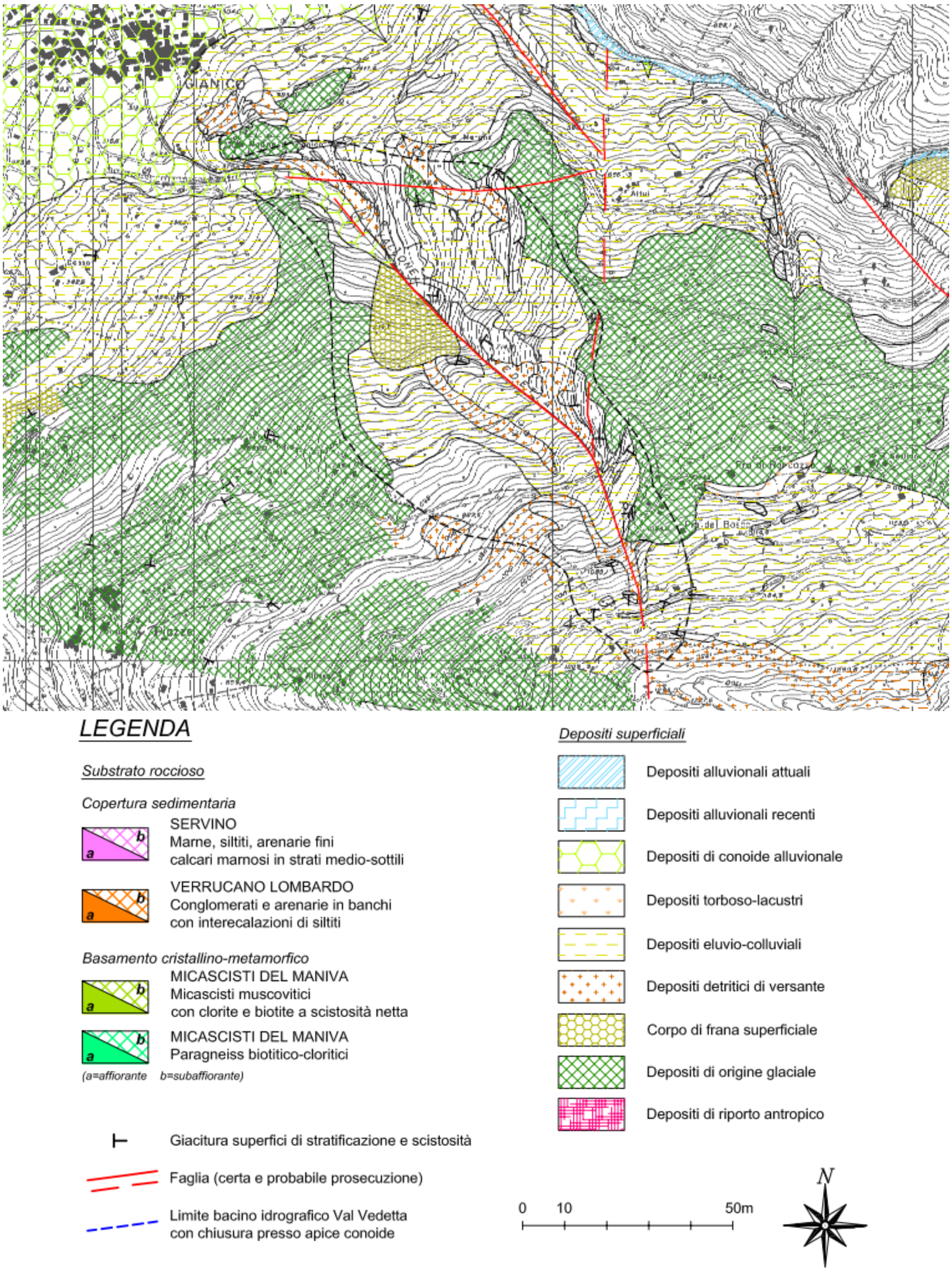


Figure 2 Geological map of Valle Vedetta –PGT Comune di Gianico

From a hydrogeological point of view, Valle Vedetta has a particular behavior: after the disaster of 1960, flow measurements were performed in the upstream and downstream sections of the Valley and it was clear that the water discharges measured in the downstream part were double than those of the upstream section. Therefore, it was inferred that between the two sections there was an important quantity of water coming from the subsoil. This hypothesis was confirmed by a series of geophysical investigations, explaining that water circulation in Valle Vedetta is divided in two components: the superficial water component is influenced by rainfall, and the groundwater component, that mobilizes landslides, flows in the deep-seated fractures of the crystalline rock. The groundwater component depends on rainfall too, and this is shown in the Figure 3: a peak of about 60 mm of rain generates an increase in the piezometric head of 2 meters, after about one month. This long time delay of discharge increases strengths the opinion that groundwater comes from considerable depth : therefore the bedrock lies at about 40-50 m from the ground surface.

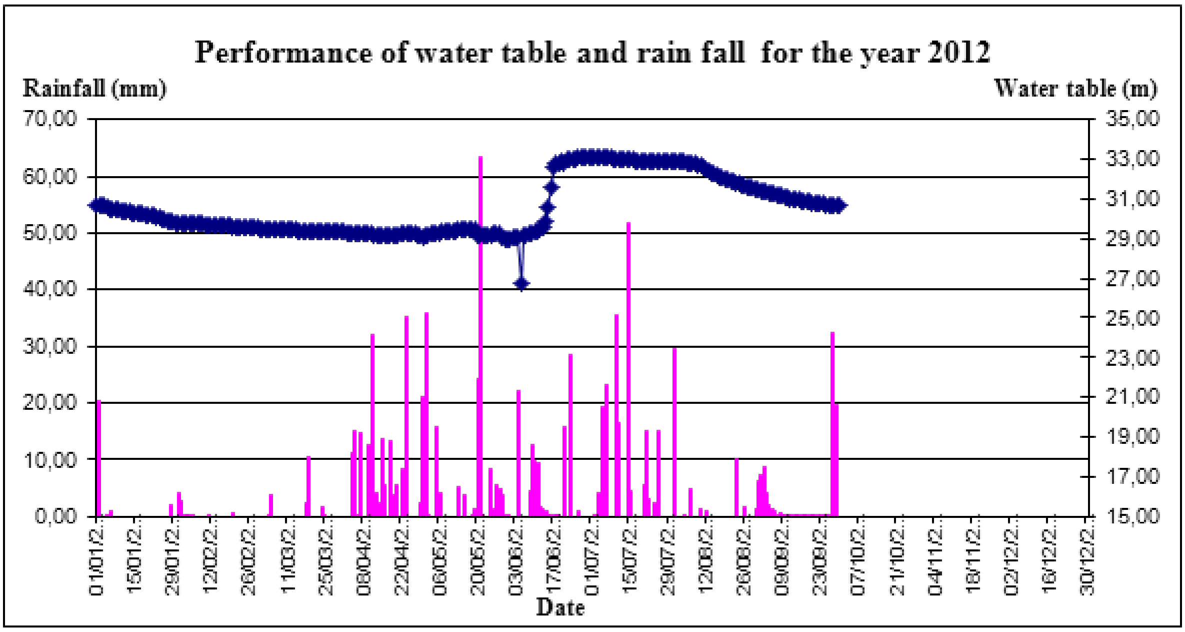


Figure 3 Performance of average water table (blu line) and rainfall during 24 hours (rose line)

After the flood of 1960, many defensive works had been built against debris flows, such as dikes and embankments. The most important of these was the drainage tunnel, called "Taglione gallery", built simultaneously with a drainage canal. Unfortunately, these works turned out to be inefficient: drainage tunnel captured a very small quantity of water and the drainage canal became dry after few meters.

In 2002, after a rainy month, the landslide along the river banks had been reactivated, so the Administration decided to intervene more vigorously, with works designed to protect the population from debris flows. Dams were reinforced by using Lasar panels and some important tools, such as a piezometer, a rain sensor and an inclinometer, were installed for monitoring the slope; in order to consolidate the head of the landslide, engineering structures made of natural wood were built as channels for surface drainage and high vegetation was cut along slopes in order to stop the active erosion. The last operation performed concerned the part of Valle Vedetta that flows closely to the region: it was necessary to remove the obstacles to the normal flow of water and contain the stream's flow into the natural bed, by building trapezoidal embankments.

Particular attention is given to the inclinometer which can survey slope's displacement by using a probe. The results of the surveys, reported in the Figure 4, show the presence of large deformations at the depth of 40 meters, with a horizontal displacement of 13 meters. The depth found is such that the phenomenon can be classified in the category of deep-seated gravitational deformation.

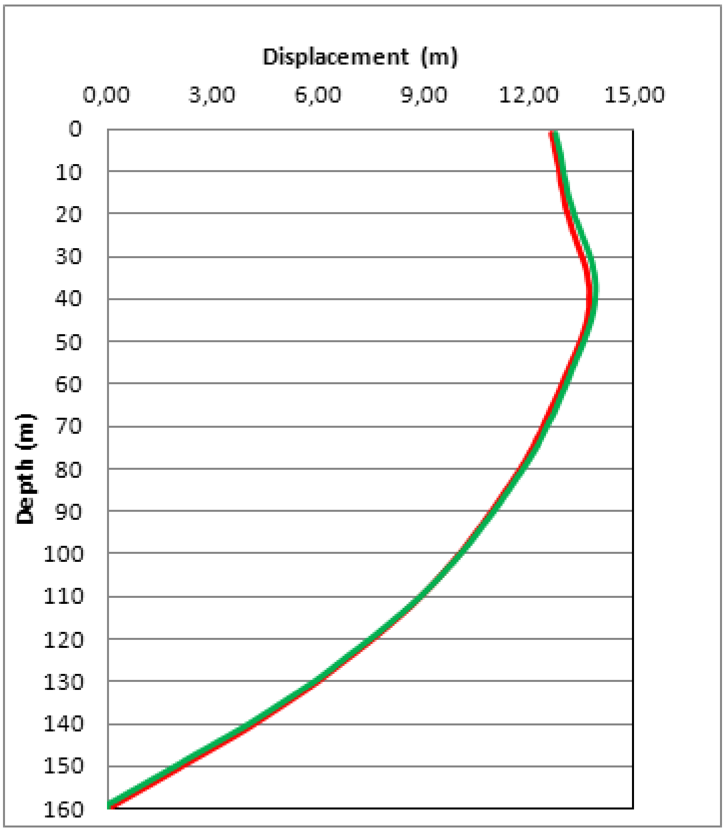
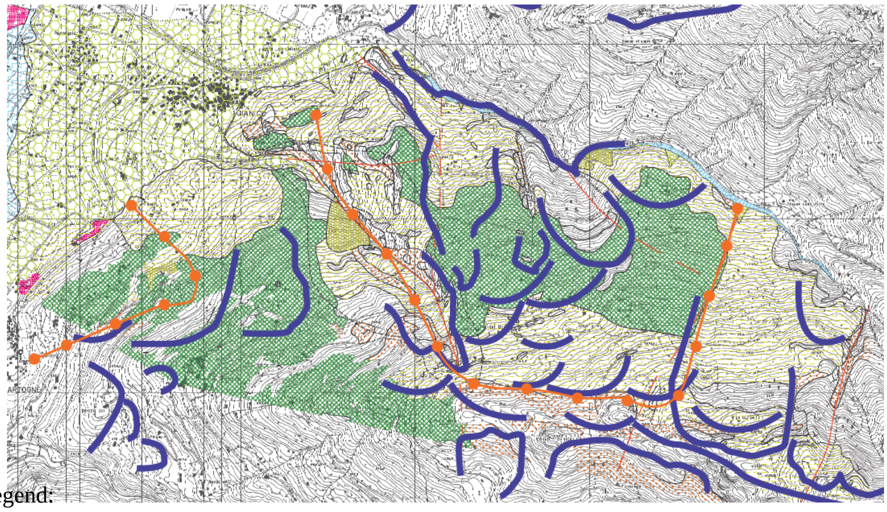


Figure 4 Representation of the result of inclinometer. Monitoring of September 2005 (in red line) and monitoring of October 2010 (in green line)

It can be mentioned the work by Ambrosi and Crosta (2005), who analyzed these phenomena in Valtellina; unfortunately, the Valle Camonica area wasn't included in their studies, but geological surveys demonstrated that Gianico area is largely affected by deep trenches due to gravitational deformations (blue lines in the Figure 5), similar to those described by the Authors (Alberti F., 2003)



Legend:

deep trenches due to gravitational deformations;

surface of gravitational shipment;

Figure 5 Map of deep gravitational deformations

To solve problems related to deep landslide in Valle Vedetta, a similar situation present in Vallemaggia (Canton Ticino) described by Eberhardt (2006) was examined. This area is affected by a deep-seated landslide in crystalline rock, which presents at 300 meters of depth a volume of 800 106 m3compromised by a series of fractures. A series of geophysical surveys have revealed a shift equal to 5 cm/yr, which damages roads and monuments erected on the sliding mass.

It was necessary to prepare a designing in order to stabilize the area: a diversion canal in order to solve the problem of erosion and a tunnel for the drainage of deep water, supported by a series of wells for the collection of the water, were built simultaneously. The flow drained by the tunnel was equal to 30 l/s. The effectiveness of these interventions was tested by a discrete model based on a hydro-mechanical approach. The model compares the two proposed solutions and verifies their efficiency over the time. Before using the model for time simulations, the parameters describing the permeability of the sliding mass and the distribution of the water pressure must be entered in the model. By permeability tests in situ and by piezometric measurement done by Eberhartd, Bonzanigo and Loew (2007), the permeability is estimated to be 7*10-6 m/s and the water-bearing stratum is confined.

Then the model is applied to a schematic section of the zone that must be stabilized, in case the stream is deflected, for which no erosion occurs. The result shows that the displacement of the sliding mass is slightly reduced, compared to the situation of erosion. If the sliding mass increases by ten times, the horizontal displacement will drop, but it will not completely disappear. The effectiveness of this work is therefore only partial, because it reduces the effects of erosion but it doesn't eliminate them completely, with consequent lack of the complete stabilization of the area. Applying the model to a schematic cross-section of the sliding mass with the drainage tunnel, the Authors noticed that as time increases, the horizontal speed tends to zero.

Therefore, considering deep drainage the best intervention to solve the problem in the Valle Vedetta eleven sub-horizontal drains have been placed in the head of the landslide, arranged in a fan, in order to penetrate into the bedrock and drain the water circulating in depth. The drained water is collected in a buried pipeline that will convey it to the municipal water supply. The flow rate drained is about 2 l/s.

Using experimental curves reported in the Figure 6, according to Desidieri, Milaziano e Rampello (1997), it's possible to calculate the efficiency in the system of drains, equal to 60%.

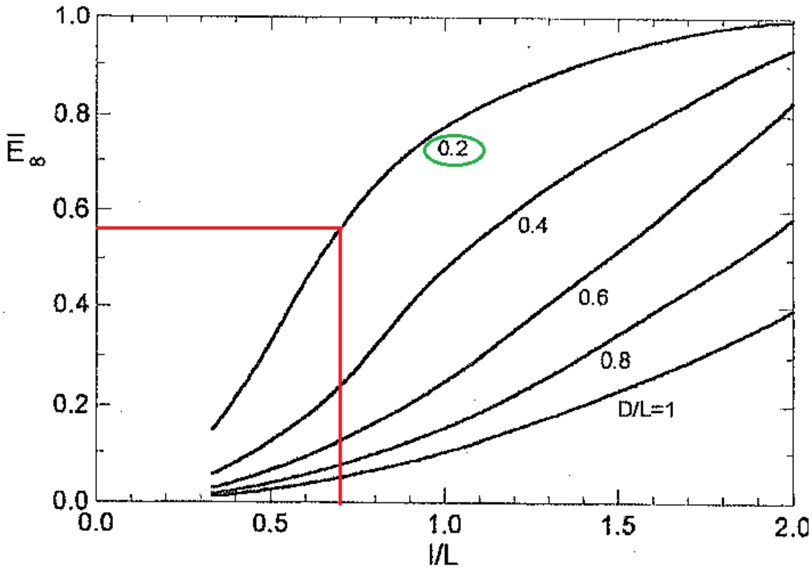


Figure 6 Experimental curves which describes the efficiency in the system of drains

The flow drained from the pipes has a minimum value, so it is recommended a further extension of drains or a possible repositioning in order to better penetrate into the bedrock: this action would increase the flow of the drained water and therefore the area should reach the condition of stability in a faster way.

3 CONCLUSION

In conclusion, It can be stated that the main cause of instability in Valle Vedetta is linked to deep-seated gravitational deformations, which generate casting landslides, especially during periods of heavy rain. The continued occurrence of flood events and of debris flows of the Val Vedetta related to anomalous depth and areal extension of debris cover. The study found that:

1) much of the debris comes from the breakup of bedrock, affected by deep seated gravitational movements;

2) in fractured rock groundwater have been found , promoting instability;

3) deep and long trenches are forming afterwards the bedrock deformations and break -up, that make very large debris masses moving towards the Valle Vedetta.

The problem of casting material was resolved by interventions aimed at the construction of dams and embankments and the elimination of possible obstacles to the normal flow of the material.

The problem of water circulating in fractures is currently being faced by the sub-horizontal drains, and, considering the results obtained from the case of Vallemaggia, this work should lead to the achievement of stability. The flow drained from the pipes has a minimum value, so it is recommended a further extension of drains or a possible repositioning in order to better penetrate into the bedrock: this action would increase the flow of the drained water and therefore the area should reach the condition of stability in a faster way.

4 REFERENCES

Alberti F., (2003), Indagine Geologica sui fenomeni franose della Valle Vedetta, Darfo Boario Terme.

Alberti F., Bertoni P. F., Mattioli S., Antonioli E., (2003), Progetto preliminare generale per i lavori di sistemazione della Valle Vedetta in comune di Gianico.

Alberti F., Bertoni P. F., Mattioli S., Antonioli E., (2012), Progetto definitivo ad intervento di consolidamento dei versanti e sistemazione idraulica della Valle Vedetta in comune di Gianico (BS), Gianico.

Ambrosi C., Crosta G.B. (2005), Large sackung major tectonic features in the central Italian Alps, Milano.

Eberhartd E., Bonzanigo L., Loew S. (2007), Long term investigation of a deep seated creeping landslide in crystalline rock. Part II. Mitigation measures and numerical modeling of deep drainage at Campo Vallemaggia, Bellinzona.

Desideri A., Miliziano S. & Rampello S. (1997), Drenaggi a gravità per la stabilizzazione dei pendii, ed. Hevelius, Benevento.

Idromin Milano (1967), Prospezione geofisica ad integrazione dei dati geologici di superficie, per lo studio del dissesto franoso della Val Vedetta, Milano.

Villa F. (1967), Relazione geologica geomorfologica e idrologica sulla zona di Gianico (Brescia), Milano.