An event in periglacial Mont Blanc area: the Arp Vieille Dessot avalanche in Val Veny , Courmayeur – AO (IT)

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ABSTRACT: In the last decades, various catastrophic avalanches occurred in the valley of the Mont Blanc from summits with an altitude greater than 4000 m a.s.l. Usually, on the orographic left side of Val Veny, several catastrophic events present an avalanche dynamic affected by glaciers and rock walls.

The paper reports an unusual event of the Arp Vieille Dessot's avalanche who occurred in May 2013 realising from a low altitude (2300m asl) on a steep grassy slope. During the second half of April 2013, several storms led 1 m of new snow at 2000m asl on the Mont Blanc Italian side area.

Caused of this, on the first half of May, various slabs with more than 1m of thickness released from the Arp Vieille Dessot's basin. On the levees of the Dora di Veny river, the avalanche deposited a large mass of snow more than 10m height and 300m wide.

Thanks to an interdisciplinary back-analysis, the release and deposition zones were estimated together with the minimum energy of the avalanche flow able to uplift and move a boulder of 40 tons and 15 mc from the riverbed to the close road.

These informations are essential to estimate the increase in avalanche destructive power in relation with eroded materials.

KEYWORDS: avalanche cadastre, avalanche dynamics, granite boulder, destructive energy.

1 INTRODUCTION

The paper presents an avalanche phenomenon occurred within the Val Veny, one of the small alpine valleys of Courmayeur (Valle d'Aosta - IT) municipality. This valley is strongly influenced by the presence of the Mont Blanc massif and several other mountains with an altitude of over 4.000 m a.s.l. and an environment shaped by the constant presence of large glaciers and where natural phenomena heavily modify its conformation by slow (as glacial ones) or quick (as rock & snow & ice avalanches) dynamics.

The main characteristics of Val Veny is the high steepness of its slopes: the medium difference between the top of mountains and the bottom of the valley is around 3000 m. From the snow avalanche point of view, this geomorphological feature could lead to the propagation of rapid events with large size and high destructive power. In the last decades, in fact, several catastrophic avalanches, strongly affected by glacial dynamics, occurred on the orographic left side of the valley. Due to their destructive dimension, these events caused deaths, widespread damage to buildings and woods, and that's why they are strongly still alive in the memory of the people attending the valley or studying the avalanche release mechanics.

However, the article focuses on an avalanche phenomenon quite different from those just mentioned and of which, in the past, only few details are known. That's why now, the Avalanche Warning Service of the Aosta Valley is trying to collect information to enrich the database of regional avalanche cadastre (http://catastovalanghe.partout.it/) and to better understand the dynamics of this avalanche.

2 THE ARP-VIEILLE AVALANCHE BASIN

The Aosta Valley Region, located in the far north-western part of Italy, borders to the north and west with Switzerland and France and more than 60% of its territory is above 2000 m a.s.l. of altitude. The phenomenon described in the following pages falls within the territory of Courmayeur (1.224 m a.s.l.), a municipality located in the western part of the region (Fig. 1). Near to the border with France, close to Mont Blanc

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(4.810 m), near the merge between the rivers Dora di Val Veny and Dora di Val Ferret, which, together form the river Dora Baltea, that then crosses the entire region. It is an area very prone to many avalanches; every year several large avalanches take place, some of them really of big size and sometimes with serious consequences. An example is the *"Glacier de la Brenva" avalanche* (Fig. 2)who triggered in January 1997 and caused 2 deaths, 15 injured and catastrophic damages to the forest.

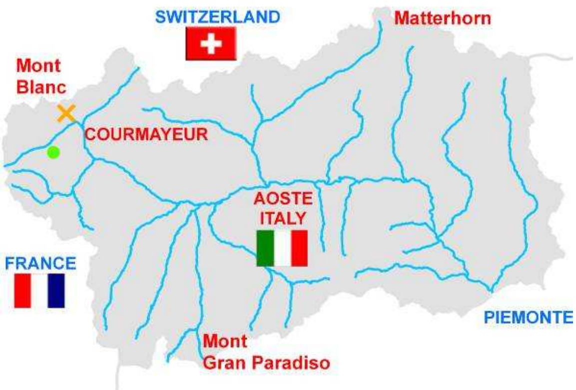

Figure 1. Map of Aosta Valley – Italy. The spot localizes the Arp-Vieille avalanche basin, while the cross represents the large size avalanche of "Glacier de la Brenva" released in January 1997.

From the municipality of Courmayeur, along the Dora di Val Veny river we come to the study area. The avalanche released from a steep slope just above 2300 m s.l.m., under the peak of Mont-Fortin (2754 m) towards the mountain huts of Arp Vieille Dessot (2068 m) and the levees of Dora di Veny's river (1944 m) (Fig. 3).

Figure 2. January 18th, 1997: the big avalanche of "Glacier de la Brenva" in Val Veny - Courmayeur (Aosta Valley), Italy (Photo: Maurizio).

The considered avalanche basin is located on the orographic right side of Val Veny at an altitude around 2300 m a.s.l. characterized by a steep grassy slope and the absence of permanent glacial formations. Therefore, the right side of the Val Veny has a completely different morphology than its opposite side, marked by glaciers and sharp rocks and jumps and, for this reason, its environment seems to be more "friendly" than the facing tall spurs along the basin of the Glacier du Miage, such as the massif of Mont Blanc (4810 m a.s.l.).

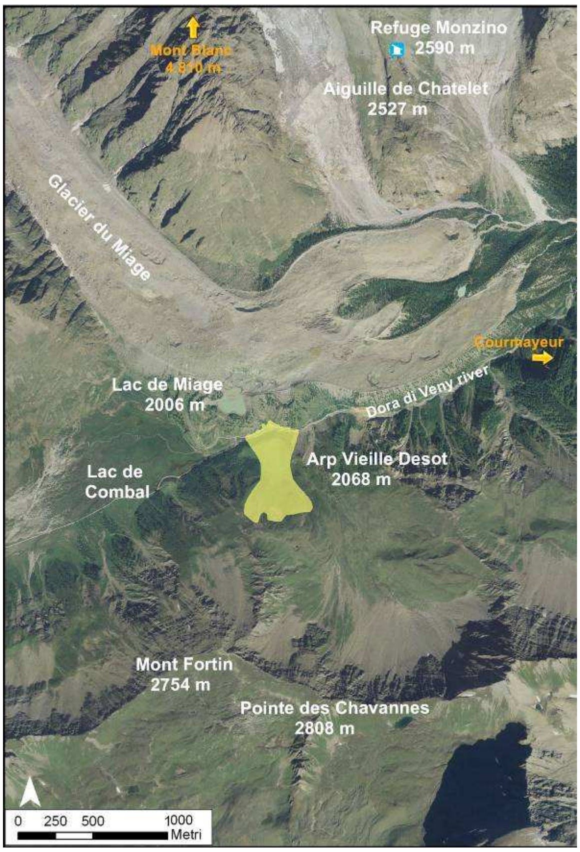

Figure 3. Localisation of the Arp Vieille avalanche basin (in the middle in yellow) that includes the Dora di Veny river.

3 THE AVALANCHE EVENT OF MAY 2013

The analysed avalanche event released in spring 2013 after several and plentiful snowfalls at high altitudes. During the second half of April 2013 infact, several storms provided new snow who's height exceeded the meter at 2000 a.s.l. averaging the whole region. The last of these storms, coming frm the south and characterized by a snow/rain limit close to 2200-2500 m a.s.l., occurred from the last days of April and the early ones of May: the new fresh snow settled on the ground was quite wet up to 3000 m a.s.l.. New snow, wind and mild temperatures at high altitude are typical triggers of medium - and in some cases large – avalanches [RAVA 2013].

3.1 The avalanche dynamics

During the first half of May 2013, the weather and snow conditions were favourable to the formation of the *Arp Vieille* avalanche: in the Val Veny the snowcover was very thick and wet above 2000 m and its stability trend decreased till the rupture of the low balance keeping the snow anchored to the steep slopes of the Arp Vieille Desot (2068 m) took place. Therefore, the detachment of several slabs with a thickness greater than one meter originated in the first days of May from the top of the avalanche basin at about 2310 m a.s.l. with an extension of about 500 linear meters (Fig. 4).

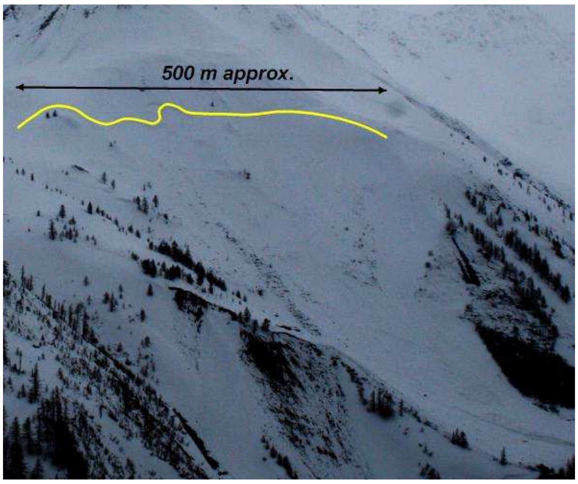

Figure 4. The starting zone of Arp-Vieille avalanche: the line follows the position of the released slabs.

The Arp-Vieille basin is an emblematic avalanche basin: the high inclination of the slope and its regularity (about 40° - Figg. 4 and 5), the absence of tall trees with the presence of vegetation primarily composed by grasses and small shrubs (blueberries and juniper) are factors that prone the site having detachment of slabs over a large surface (Figg. 4 and 5). The snow flow moving quickly rushes towards the valley following the shape of the basin starting grouped and, at about 2000 m, expanding up to affect the flat grassland used by steers and cows in summer.

The avalanche flow reached a maximum width of about 310 m just before crossing the lower limit of the meadows where the slope, populated by a dense cover of shrub of green alder, becomes rugged and steep (about 35-

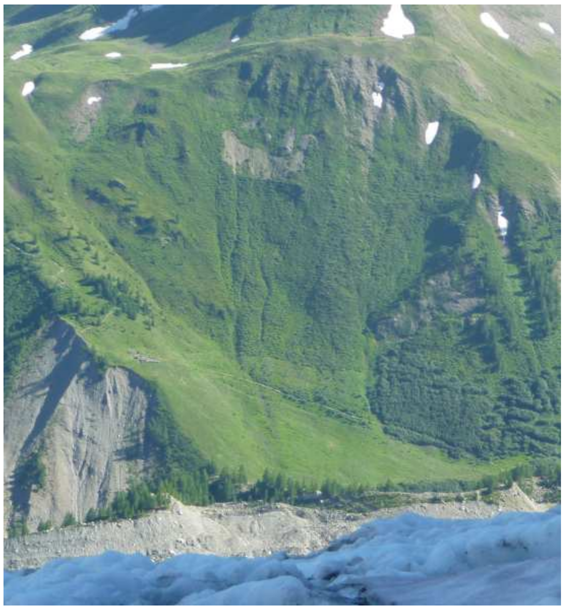

Figure 5. The avalanche basin view from the opposite slope, the Glacier du Breuillat at around 3000 m as.l..

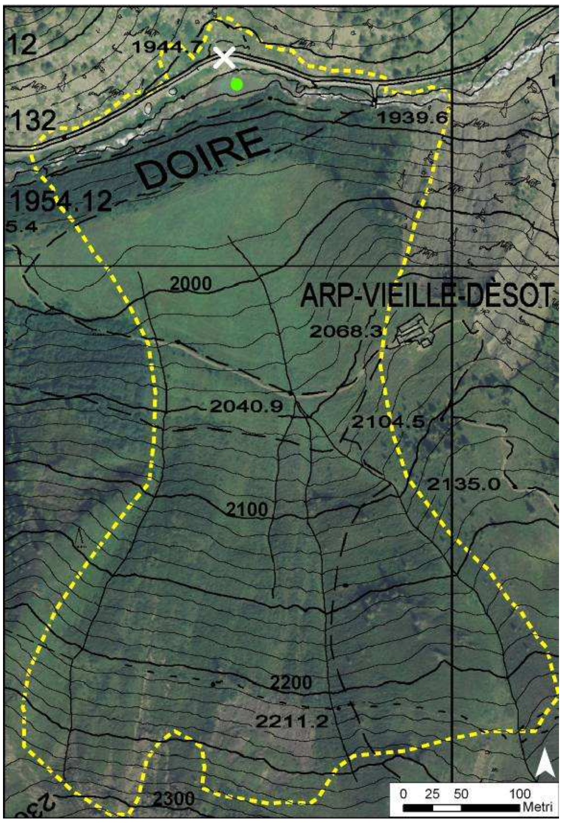

Figure 6. Map of Arp-Vieille avalanche basin of May 2013. The spot indicates the initial position of granite boulder into the river, while the cross the position where the avalanche moved it. The cartographic support consists in ortophotocarta merged to regional technical map in 1: 10.000 scale.

40°). The avalanche fell towards the bottom of the valley with greater force and very quickly reached the bed of the Dora di Veny river at 1940 a.s.l.. Here, it plunged into the icy waters and, thanks to the huge accumulated energy during its propagation, removed, from the river, a large amount of fine deposits (sand) and a massive boulder. One branch of the flow overcame one of the ridges of the avalanche basin and headed to the steep and rocky slopes located downstream of the Arp-Vieille Desot pasture. The deposit affected more than 360 m the river's bed and the close farm road, and went up the opposite slope for more than 30 linear meters (Fig. 6). Near the Dora di Veny, a large quantity of very wet snow was deposited. In some places, the accumulation plenty exceeded the 10 m of height, enough to cover large stretches of the river until late summer (Fig. 7).

Figure 7. The thick avalanche deposit in June 2013, 30th. Note the river, the farm road and the granite boulder that emerges from the snow in melting process (Photo: P. Deline).

Figure 8. In late July, the boulder still rest on the avalanche deposit. Note the sand of the river on the snow close to the boulder.

4 SURVEY POST-EVENT: THE GRANITE BOULDER ON THE FARM ROAD

In June, the massive avalanche deposit was gradually melting uncovering the massive boulder who was moved by the avalanche flow (Figg. 7 and 8). The granite boulder previously was located approximately at the center of the river's bed of, about 16 m from the farm road that runs along the stream. After the avalanche interaction, the boulder was found drowned inside the wet snow mass just above the farm road, shifted by about 18 m and 7 m in planimetric and altimetric distances, respectively (Fig. 6).

Figure 9. The panoramic view of river Dora di Veny: on the right, note the boulder in its original location. In the background the Pyramides-Calcaires (photo Citizens - Panoramio).

Having a significant size, the boulder raised immediately a lot of curiosity. At first, it is not obvious where the boulder came from: it was assumed that it may had fallen from the steep slopes of the moraine of the Glacier du Miage. But the discovery of a lot of sand inside the avalanche deposit and some photographs (Fig. 9) testify the presence of the boulder in the river making clear what happened.

The boulder is a meta-granite of Mont Blanc coming from the steep slopes that surround the glacial basin of Miage. It is estimate that the boulder has a volume of close to 15 mc and a weight of about 40 tons with a maximum height and width of 3 m and 5 m, respectively and depth slightly higher than 3 m (Fig. 10).

Combining the data of the boulder with those relating to its displacement, it was possible to estimate the minimum forces of the avalanche flow. Trying to calculate them allows us to better understand how the destructive power of an avalanche, characterised by not-extreme size, can be very dangerous and how its destructive potential can increase in function of the type of motion and snow during their propagation.

Thanks to a physical basis, depending on the limited information collected, it was attempted to estimate the speed of the avalanche at the bottom of the valley (riverbed) thanks to the approximate calculation of minimum energy required to move the boulder form the riverbed to the middle of the farm road.

Figure 10. The dimension of the granite boulder in comparison with ones of forecaster of Avalanche Warning Service of Aosta Valley. In the background the Arp-Vieille avalanche basin in summer version.

Calculating the work needed by the granite boulder to move itself from the undisturbed position at the riverbed (segment AB), then lifting itself from the bottom of the riverbed to the road (segment CB) and then dragging over to the side of the rugged road (segment CD), it was possible to estimate the push induced by the avalanche (Fig. 11).

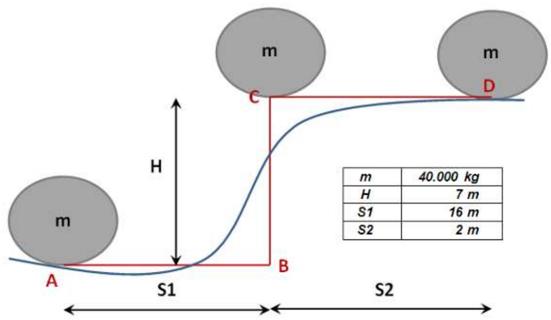

Figure 11. Schema of the displacements induced by the Arp-Vieille avalanche on granite boulder from the riverbed of Dora di Veny to the side of closed rugged road. In particular, m indicates the mass of the block and S1, S2 and H induced displacements.

Considering that in the D position the boulder presents zero speed, thanks to the calculation of the total work done by the most simple forces, we can have an estimation of the scale of boulder speed, directly related to the avalanche velocity.

Obviously, the calculation is strongly approximate since, besides being unknown the dynamic mechanisms which has led to the displacement of the block, the avalanche's variables of time and speed (or acceleration) and the deceleration (or friction) that has led to the filing of the boulder on the road are unknown.

The estimation was therefore carried out on a parametric way varying the speed of the block at point C (at the edge of the road). Neglecting mechanisms by which the avalanche induced the movement of the boulder (it was first raised from the riverbed and then transported as a debris or, maybe, it has been impacted and set in motion?), the types of motion of the boulder (along the segment CD, the rock slowed only because of snow friction or it was transported by the flow avalanches as a raft by the waves of the sea?), the calculation was performed by simply considering the energy expended by the avalanche flow to displace the block through the work of a force. So, only the kinetic energies of the boulder with respect to the distance S1 and S2 and the potential energy on the gradient of height, H were considered. Then, varying parametrically the speed at point C, the graph shown in Fig. 12 can be drawn. Note that for a reference speed (in point C) that ranges between 1 and 5 m/s, the boulder presents an initial velocity induced by the avalanche (in point A) of about 13 m/s.

5 CONCLUSIONS

The article presents the real case of an avalanche occurred in the spring of 2013 in one of the valleys of the Italian side of the Mont Blanc Massif - Courmayeur (Aosta - IT). Fallen in a not populated area, the peculiarity of the event was to deploy a granite boulder of about 15 mc from its "home" in the torrential riverbed to a rugged road of the valley, close to the river.

The fact has also aroused scientific interest both from the point of view of avalanche dynamics and the estimation of the power induced by snow flow. Unfortunately, the collection of information has not led to the understanding of the mechanisms induced by the avalanche to relocate the boulder.

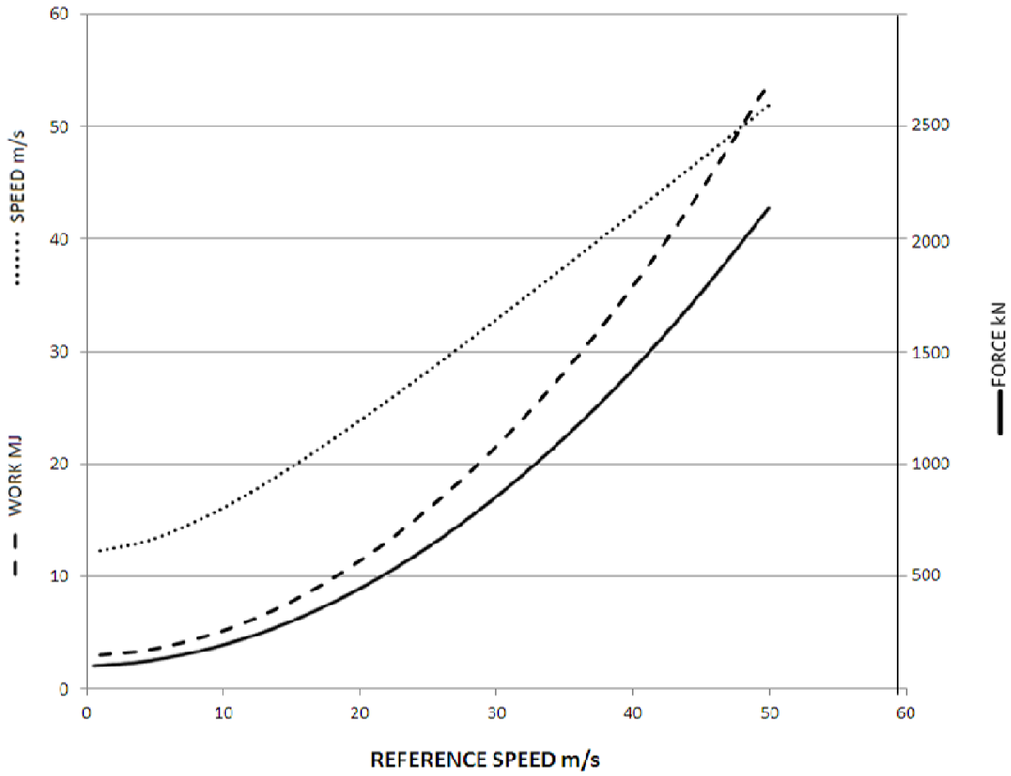

Figure 12. The trend of the force (solid line), the related work (dashed line) and the minimum initial speed induced by the avalanche to the rock (dotted line) required to displace the granite boulder from point A to point C as a function of the speed reference – in point C

Considering these limitations, thanks to an approach with a basic physics, the order of magnitude of the minimum speed of the avalanches flow to produce the energy coping with the displacement of the boulder was estimated.

Future developments of the analysis will see the support of a numerical simulation of the event to improve the knowledge on the speed, energy and flow height of the avalanche at the location of sand and rock in the riverbed (point A) and those data will be compared (perhaps utopistically) to better understand the possible mechanisms of dislocation of the boulder.

6 ACKNOWLEDGMENTS

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