SNOW WITH SAHARAN SAND. HAZARD EVALUATION AT A LOCAL SCALE

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ABSTRACT: The cyclonic events of Atlantic origin associated with sirocco winds in most cases result in precipitation that contains reddish dusts. These sediments come from the wind erosion of the sand stretches in northern Africa and in particular from the desert areas of the Sahara.
Along the southern slopes of the Alps, these events entail, at the end of the cyclonic event, either the presence of a thin layer of reddish dust in case of rain or the deposition of "red snow" in the winter periods.
In recent years, these events have recurred almost regularly at least once per winter season. The presence of a layer of "red snow", on the snowpack or inside it, requires particular attention in the evaluation of the potential problems that snowpack can generate over time.
Starting from the nivological and stability analyses carried out on snowpacks containing "red snow", together with the analysis of the avalanche activity, the proposed study presents some considerations related to the predisposition of snowpacks containing layers polluted by Saharan dust to develop avalanche phenomena caused by the initial incorporation of the "red snow" layer into the snowpack up to its consequent melting.

KEYWORDS: red snow, saharan sand

1. INTRODUCTION

This work presents the experience that the authors have gained over years of snow surveying activity related to snow coverings containing layers polluted by Saharan sand.
Starting from the origin of the phenomenon, this study points out the critical issues that the mantles containing layers of desert dust can generate in the snowpack stability and in terms of propensity to detachment of the mantle that has deposited above the layers of red snow.

2. ORIGIN OF THE PHENOMENON

At a synoptic level, in the 70s Prodi F. and Fea G. (Neve e Valanghe N. 88 - August 2016) identified the weather conditions that may favour the occurrence of precipitations containing desert sand in the southern alpine area. The event is generally associated with the occurrence of Atlantic perturbations associated with cold air of polar origin at a height that favours the deepening of the trough towards southern latitudes, allowing the jet streams to transit over the regions of North Africa, intensifying the winds in the lower layers with the consequent development of erosion phenomena of the Sahara desert expanses and the raising of sediments. Associated with the phenomena of lifting, there are the scirocco winds that transport the desert dust at high-altitude (3000-5000 m) from the southern latitudes up to the latitudes of the Alps. The interaction of the scirocco winds with the alpine mountains determines rainfalls or snowfalls containing reddish sediments of Saharan origin.

3. CHARACTERISTICS OF RED SNOW

The snow with Saharan dust, compared to the snow free of impurities, loses in part the ability to reflect the incident solar radiation (albedo reduction) favouring the phenomena of fusion and the phenomena of destructive metamorphism with the creation of crusts generated by the melting cycle and subsequent refreezing (crystal type MFpc and MFcr).
The red snow layer, if it is not covered by other precipitations, accelerates the phenomena of melting and mantle reduction. If, on the other

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hand, it is incorporated in the snowpack, it represents a potential layer of slippage that can predispose the mobilization of the mantle placed above it.
Also in the case of reddish crusts, the blocking of the steam flow associated with a thermal gradient favours the formation of faceted crystals (FCso and FCsf type crystals) that further favour the sliding conditions of the snow layers placed above.
From the observations made during the 2008-2018 period in the mountainous area of the Southern Pennine Alps, the snowfalls that deposited red snow occurred in the period of early winter (January) and spring (April) and were always covered by subsequent snowfalls.

In the following pictures, there are some examples of snowpacks, for the seasons 2013-2014, 2015-2016, 2017-2018, where the layer of snow with Saharan dust is clearly visible.

Season 2013-2014
Fig. 1 clearly shows the reddish layer located in the upper part of the snowpack detected in the area of Bielmonte - Artignaga, while in fig. 2 you can appreciate the abrupt change of hardness in correspondence of the crust at about 80 cm from the surface.

Fig. 1 – View of the snowpack with the red snow layer (06/03/14)

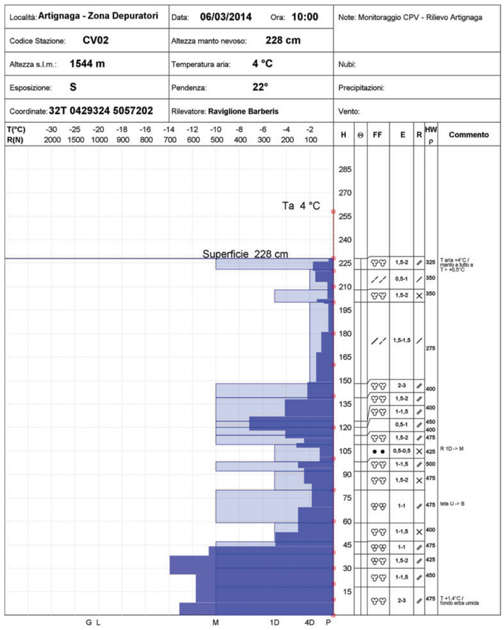

Fig. 2 – Snowpack profile of the 06/03/14 (Yeti)

Season 2015-2016
Fig. 4 clearly shows the reddish layer located on the surface of the snowpack detected in the area of the Conca di Oropa, while in fig. 3 we can appreciate the abrupt change of hardness in correspondence of the crust and the increase of water content in the layer.

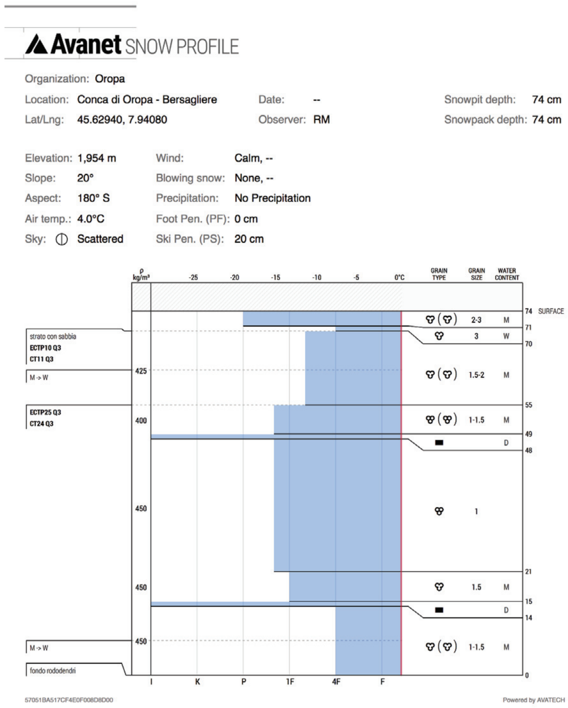

Fig. 3 – Snowpack profile of the 06/04/16 (Avanet)

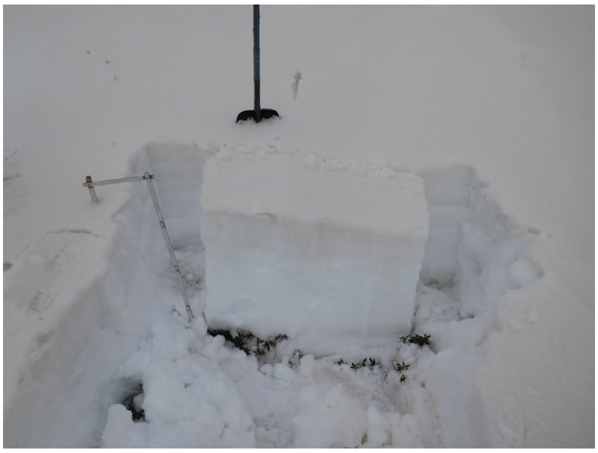

Fig. 4 – View of the snowpack with the red snow layer on the top (06/04/16)

Season 2017-2018

Figures 5 and 6 clearly show the reddish layer located respectively in the upper part and in the lower part of the snowpack detected in the area of the Conca di Oropa in January 2018 and in April 2018, while in fig. 7 you can appreciate the abrupt change of hardness in correspondence of the red snow. About 3 months later, the covered layer remains and maintains its characteristics of potential slip layer.

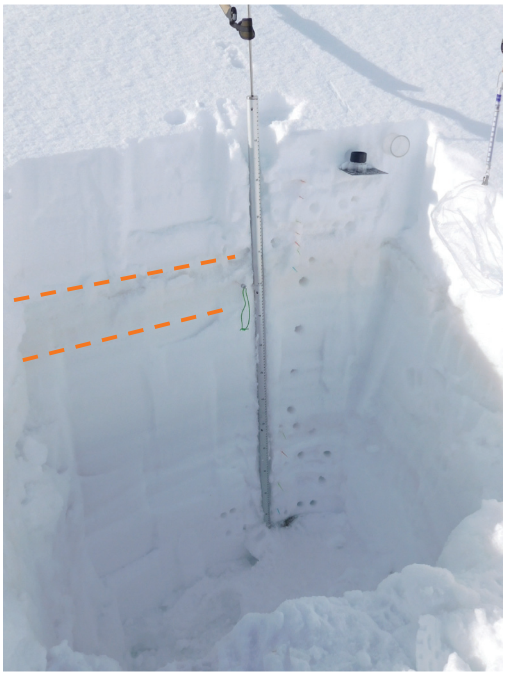

Fig. 5 – View of the snowpack with the red snow layer on the top (11/01/18)

Fig. 6 – View of the snowpack with the red snow layer on the botton (18/04/18)

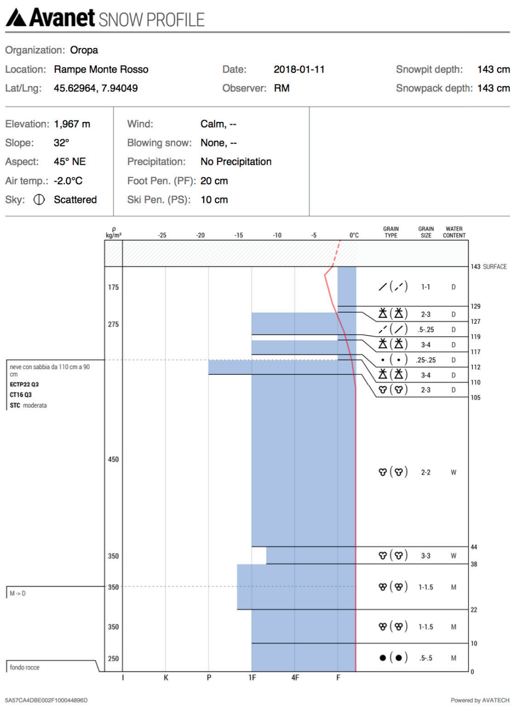

Fig. 7 – Stratigraphic profile of 11/01/18 (Avanet)

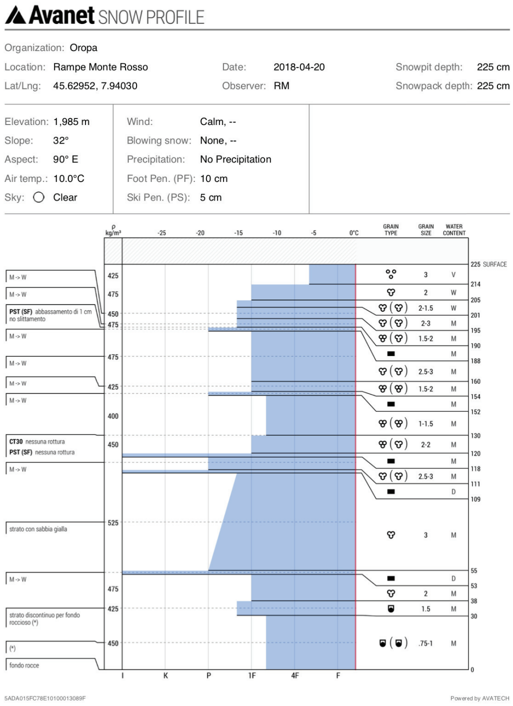

Fig. 8 – Stratigraphic profile of 18/04/18 (Avanet)

4. ANALYSIS OF THE AVALANCHE ACTIVITY

The observed avalanche phenomena that affected the red sand layer as a slip plane were mainly caused by two types of trigger: the first linked to the non-adherence of the new snowfalls with the red snow layer, the second due to the increase in liquid water content in the surface snow layer which results in the creation of a fragile layer of very humid snow - wet on the red snow layer.

Both the typologies described occurred in spring, the first due to dry-humid snowfalls and the second in correspondence of significant temperature rises or for rainfalls on the snowpack that increased the overload.

The most significant avalanche events are illustrated below, in particular those occurred in March 2014 and in April 2018, which affected the mountain sector of competence and which were characterized by detachments along the red snow layer.

Avalanches in March 2014

The avalanches in spring 2014 that affected the Bielmonte area (stratigraphic profile Fig. 2), occurred on 09/03/14 in the late afternoon and were mainly generated by a rise in temperature (without night refreezing) that affected the area and increased the water content in the mantle placed above the layer containing desert sand. The avalanche phenomena occurred mainly along the slopes with SE-S exposure where the temperature rise and the solar irradiation caused a greater heating of the mantle and increased the water content in the surface layer.

Fig. 9 – Avalanches effects in March 2014

Fig. 10 - Avalanches effects in March 2014


Fig. 11 – Avalanches effects in March 2014


Fig. 12 - Avalanches effects in March 2014

Avalanches in April 2018

The avalanches in spring 2018 that affected the Conca di Oropa area (stratigraphic profile Fig. 7 and 8), were mainly generated by the non-adherence of soft slabs on the layer containing Saharan sand even if, in the following days, loose snow avalanches of wet snow were recorded due to the increase in temperature that affected the area.

One of the most significant events, and historically already occurred several times, was the one affecting Lake Mucrone (fig.13). The avalanche broke off the northern slope of Mount Mucrone and hit the frozen surface of the lake, causing it to drop about 1 m with a consequent runoff of water resulting in a flood-wave that eroded the mantle on the ground for several hundred meters.

The peculiarity of the avalanche events in the area of the basin that were generated along the plane and that contained desert sand occurred only within the altimetric range between 1900 m and 2100 m asl, while at higher altitudes the events, generally at loose snow, did not affect the layer polluted by dust.


Fig. 13 - Avalanches effects in April 2018


Fig. 14 - Avalanches effects in April 2018


Fig. 15 - Avalanches effects in April 2018

After about 4 months from the deposition, the layer of snow with Saharan dust had not "dispersed" in the snowpack but reappeared on the surface during the melting of the mantle that covered it.

Fig. 16 – Surfacing of the layer with Saharan sand (may 2018).

5. CONCLUSIONS

The present study, starting from the observations made during itinerant surveys, made it possible to correlate the snow characteristics of the snowpack containing layers of red snow and the avalanche events that affected the area being monitored.
In relation to the correlations made, it can be stated that the layer of snow containing Saharan sand, if incorporated in the snowpack, represents a probable slip plane for the mantle placed above and that its presence persists until the complete melting of the mantle.

6. CONFLICT OF INTEREST

The authors of this study were not supported financially or materially by any entity connected to the topics of the article.

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