Avalanche in Sertig Valley on February 21, 2006

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On February 21, 2006 a dry-snow avalanche occurred in the Sertig Valley near the hamlet of Sertig Dörfli. One of its tongues missed the road only by a few meters. This avalanche was unintentionally released by a group of skiers, one of whom was partially buried by the flow but immediately rescued. In the same period, several additional avalanches occurred in the Sertig Valley, but time constraints did not allow us to investigate them.

The avalanche covered an area of 23 ha and reached a (projected) length of about 800 m, with a vertical drop of 470 m. This amounts to a runout angle of 30°. The site is an open slope with a straight track. The release area was about 400 m wide, and we estimated the release depth at 80 cm.

Fig. 1. *A panoramic view of the avalanche from the hamlet of Sertig Dörfli.*

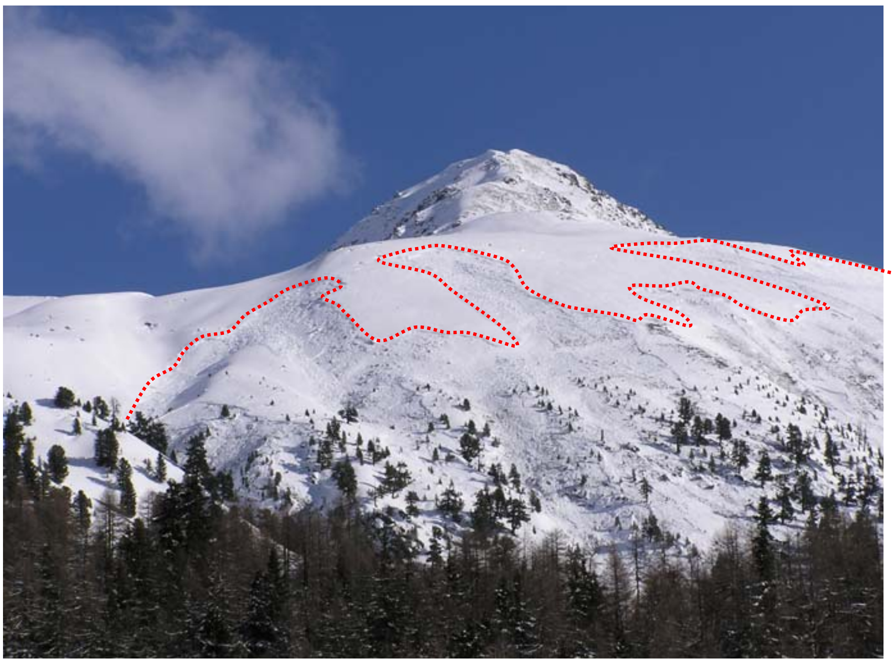


Fig. 2. *The release zone as seen from the opposite slope.*

Our field work was structured (in chronological order) as follows:

<u>Day 1</u>

- GPS mapping of the deposit zone;
- Estimationof the avalanche deposit by means of trenches in the frontal part;
- Comparison between snow avalanche deposit and undisturbed snow cover;
- Study of particular structures in the avalanche deposit;
- Measuring of snow height in a secondary release crown;
- Search for the debris source.

<u>Day 2</u>

- Study of erosion, mixing and deposition processes in one branch of the avalanche by means of a series of trenches;
- Collection of specimens for quantitative analysis of debris content in the laboratory.

Fig. 3. *The green stippled line indicates the edge of the deposit area. In the background, Sertig Dörfli is visible.*

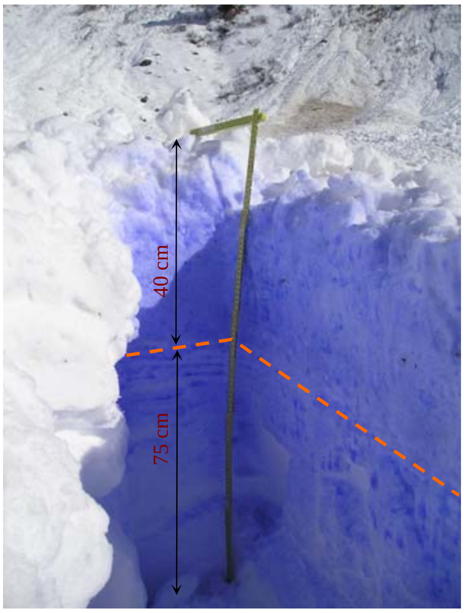


Fig .4. *First trench, in the deposit area. The hatched orange line indicates the interface between the remains of the original snow cover and the 40cm deep avalanche deposit.*

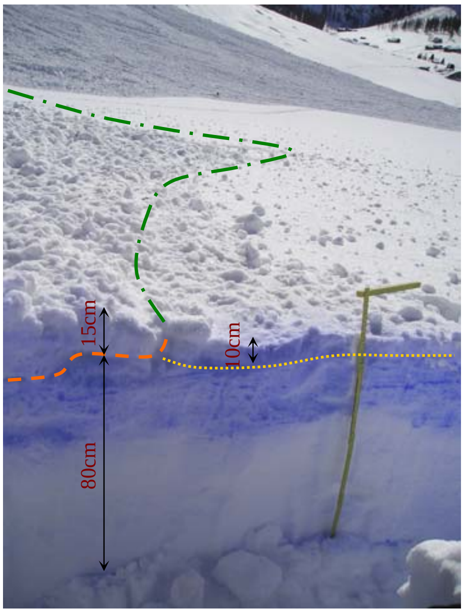


Fig. 5. *Distal part of the same trench. The green line indicates the boundary between the dense part (left) and the fluidized layer (right), where the orange and yellow lines visualize the deposit thickness.*

We made a longitudinal trench, in the frontal part, crossing the boundary between the dense and the fluidized zones (Figs. 4 and 5).

Where the original snow cover was covered by the avalanche, we found its density to increase in the upwards direction, whereas there is no similar trend in the snow cover outside the avalanche. Compaction under weight is expected, but why the layers near the surface should be compressed more strongly than the deeper layers is less evident.

Density measurements in the snowcover with the avalanche deposit in the upper part		*Density measurements in the undisturbed snowcover*	
Snow height (cm)	***Snow density (kg/m³)***	***Snow height (cm)***	***Snow density (kg/m³)***
75	**430**	*75*	**236**
65		*65*	**262**
50	**283**	*50*	**241**
30	**262**		

This avalanche – despite its considerable size and mass and the dry-snow conditions during its occurrence – did not develop a significant fluidized layer. The distal edge of the deposit was clearly defined while several soft and small snowballs ran up to 20–30m farther than the frontal part. Interestingly, no impact "craters" were visible along the trajectory of the snowballs, suggesting that they flew through the air over considerable distances (Figs. 6 and 7). One may hypothesize that they were carried over such distances by aerodynamic lift due to a powder-snow cloud. However, the snow-cover surface beyond the distal end of the deposit did not show the tell-tale signs of a powerful air flow in the flow direction. This observation suggests that the snow balls had rather high speeds (around 20 m/s) at the point where the avalanche had come to a stop.

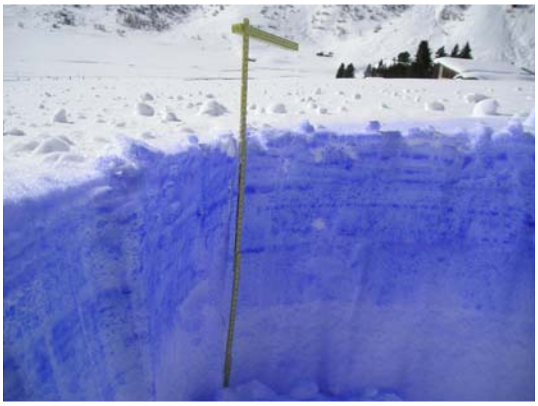


Fig. 6. *View from trench 1 in the distal direction, showing soft snowballs dispersed over the smooth surface beyond the avalanche deposit.*

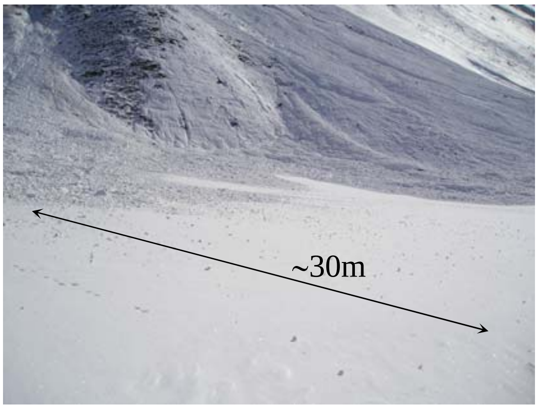


Fig. 7. *View from trench 1 to the side, showing the flight distances of the soft snowballs.*

In order to estimate the entrainment along the track and in the runout zone, two snow pits were made in undisturbed areas as well. The first (no. 3 in Fig. 9) showed a hard layer (wind crust?) about 10 cm thick a few centimeters below the surface. However, this layer was discontinuous and we found nothing similar near the avalanche front. The location of the second pit (no. 1 in Fig. 9) was chosen to give information on the snow depth and texture (in particular the presence of hard layers) on a steep slope. This allowed us to estimate the entrainment depth along the track. Again a wind crust was found near the surface again, and the remaining snow cover consisted of depth hoar. (This indicates that the avalanche could quite easily erode the entire snow cover.)
In the transition zone of the avalanche, on a similar steep slope, we observed a very hard surface left after the passage of the avalanche, with snowballs sintered to the top; their orientation is in agreement with flow direction (Fig. 8 and location no. 2 in Fig. 9). Because no corresponding crust was found in the original snow cover near the ground, we have to conclude that this hard layer was formed during or immediately after the avalanche event.

As the erosion depth differs so significantly between adjacent zones on the same slope, it should be interesting to search for morphological control factors which rule the ground erosion rate after snow melt.

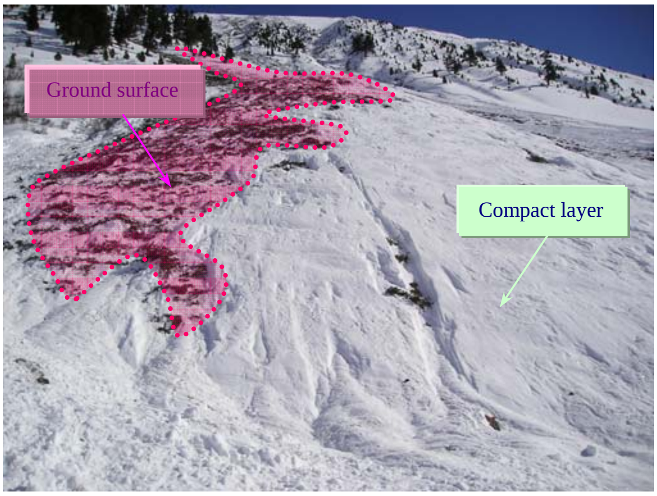


Fig. 8. *In some areas, erosion proceeded to the soil surface whereas in nearby areas part of the original snow cover remained but was covered by a hard layer.*

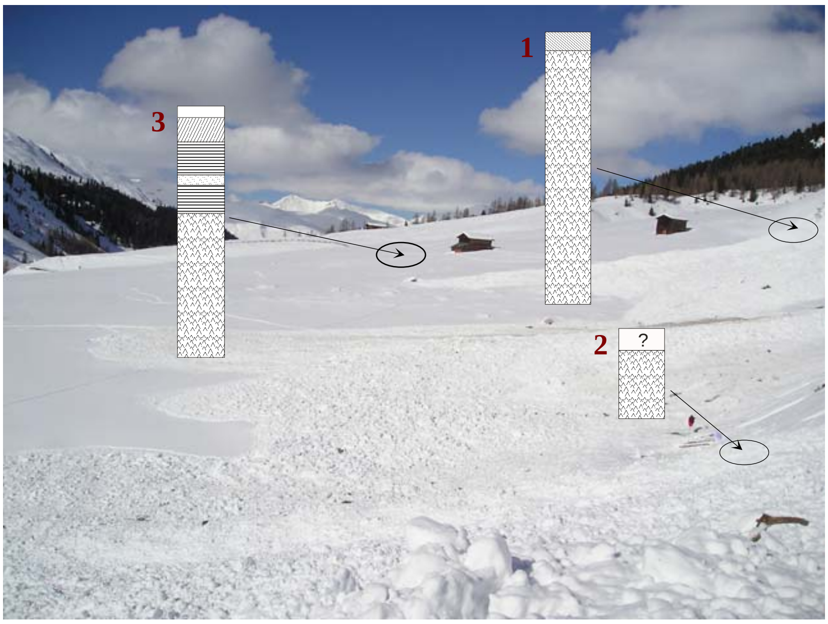


Fig. 9. *Overview of snow pit locations. Pit no. 1 is in an undisturbed slope while no. 2 is in a location where the avalanche eroded only part of the snow cover. Pit no.3 is in a nearly horizontal location.*

A secondary crown, at lower altitude than the main release, probably can be attributed to a secondary release induced by the entrainment of the snow cover by the passing main avalanche flow. The measurements (heights and densities) collected on the tensile fracture surface will be useful for the mass balance calculus. The fracture occurred at a right angle with the surface and was not perfectly flat but ragged.

Figs. 10 and 11. *The irregular, 80cm high tensile fracture line at much lower altitude than the main release.*

At the same altitude as this crown, we could recognize an avalanche branch particularly rich in debris. Therefore, we tried to find the debris source in order to evaluate the mechanism of erosion and transport of debris and its spreading in the deposit. Our main findings were the following:

- Geometry: A small spot of less than 100 m² where the avalanche clearly eroded the ground..
- Presence of liquid water: This may have played a role in facilitating erosion of top soil.
- Debris type: Clayey soil with some stones, together with a significant quantity of organic material (leaves, grass, twigs).

From that point we took photos that illustrate the debris spreading in the avalanche deposit. The material spreads in straight flow but is more concentrated at the bottom of the slope, right where the latter changes abruptly.

Figs. 12 and 13. *The debris from a small source area (encircled in photo to the right) was mostly deposited at the bottom of the slope, but two narrow "jets" are seen as well.*

The second day was entirely dedicated to the study of debris in the avalanche deposit in order to gain better understanding of the erosion, transport and deposition mechanisms. However, the enormous strength of the deposit near the root of the slope made the use of a large chainsaw indispensable in digging snow pits. We conjecture that, along with the soil, the avalanche entrained free water from a source at the same location and that this was the main reason for much harder deposits than in nearby areas.

On order to investigate the distribution of debris in the deposits, we dug three trenches that were oriented transverse to the flow direction and crossed from “dirty” to “clean” deposits. The first was near the slope base and the others 20 m and 40 m downstream, respectively (see Fig. 14).

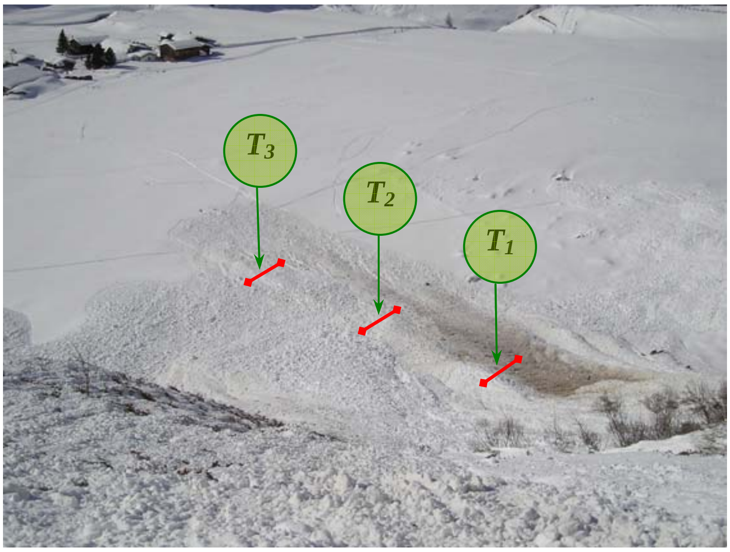
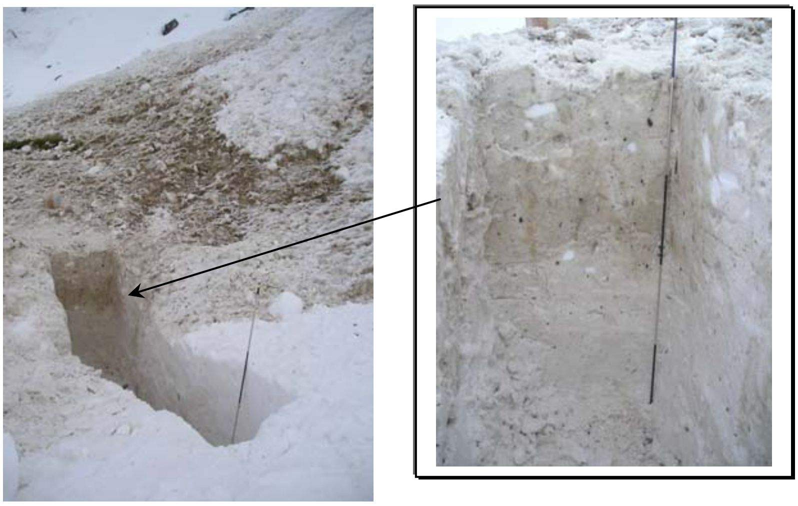


Fig. 14. *Position of the trenches in the avalanche deposit.*

In the first snow pit, the debris was homogeneously throughout the full depth and consisted mainly of soil material, pebbles and branches. This implies intense vertical mixing during the flow. The lateral edges of the “dirty” deposit were quite distinct and sharp (see Fig. 16), suggesting that lateral motion and mixing were limited. In this dirty matrix of snow and debris, several large angular snow blocks were easily recognized by their shiny white color; moreover, many ice pieces were found.

Fig. 15. *The hardness of the deposit required the use of a chainsaw.*



Figs. 16 and 17. *Trench no.1, transverse to the flow (left), and detail showing the entrained stones and topsoil (right).*

In the second snow pit, the debris was still plentiful, but it did not reach the ground base floor (30 cm depth hoar), but was separated from it by a compressed layer of white snow.
We found even more snow boulders embedded in a lighter brown matrix, mark of progressive decrease of debris content towards the flow front. Quite many big soil clods were present as well.

Figs. 18 and 19. *Trench no. 2. A big snow clod is embedded in the dirty snow matrix (above) and big lumps of soil were found inside the trench (right).*

In the last trench, the ground material percentage was lower than previous case. Here the snow was essentially white even though several twigs from bushes and small soil lumps were still found.

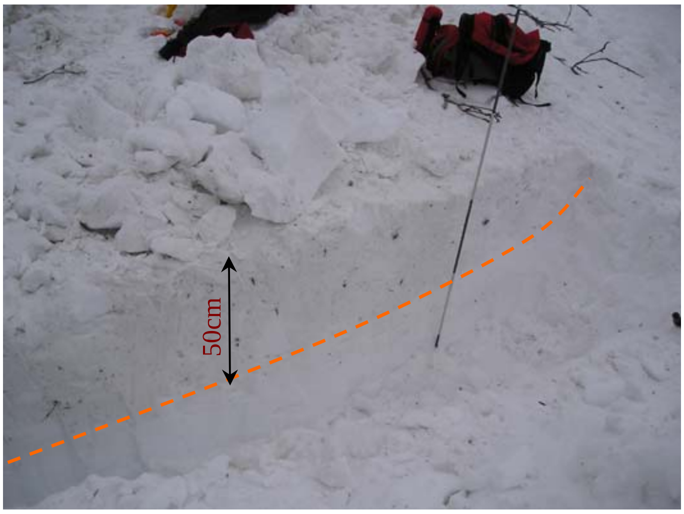
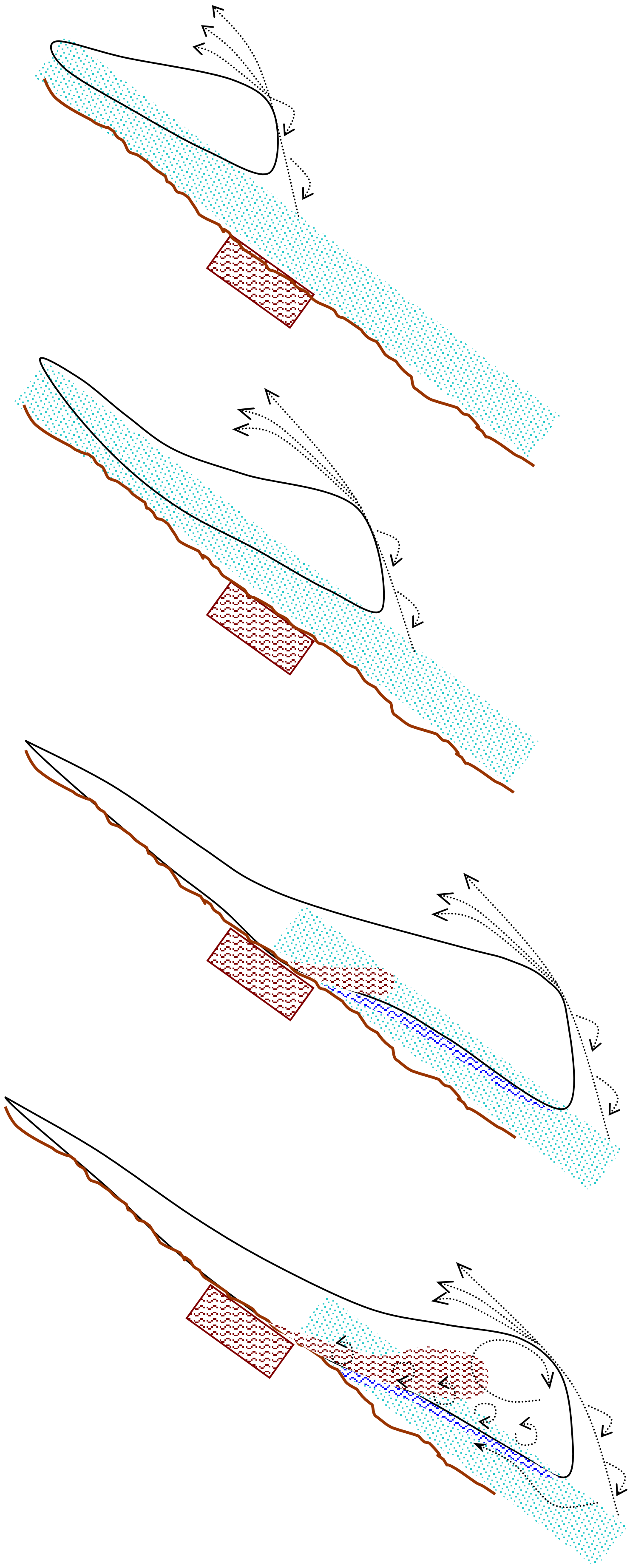


Fig. 20. *Trench no. 3: The debris concentration decreases gradually towards the front.*

The sketches on the following two pages try to illustrate how erosion of the snow pack proceeded gradually at the location of topsoil erosion and how mixing in the avalanche flow eventually distributed the eroded soil over parts of the avalanche. Mixing, however, was not isotropic but much more pronounced in the longitudinal and vertical directions than in the lateral one. This is presumably due to the predominance of shear over turbulent diffusion, even though the decrease of soil concentration in the longitudinal and transverse directions suggests a diffusive process.



Cartoon 1

Cartoon 2