NEW METHODS APPLIED TO AVALANCHE MAPPING

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INTRODUCTION

Ten years of experience in avalanche mapping and the development of the Geographic Information Systems (GIS) have allowed us to optimize the process to map and to elaborate the Avalanche Paths Maps.

At the beginning the integration of the data in a GIS was the last step of the avalanche mapping process. At present, GIS is a mapping tool and it is integrated in the process to elaborate this maps.

With these new applications the mapping process became faster and more accurate.

MAP OF AVALANCHE PATHS

This is a thematic map where the land areas affected by avalanches are mapped.

The concept of an avalanche path refers to the area in which there has been avalanche events with different sizes. Its limits are given from the maximum avalanche that the different signs actually existing (geomorphologycal, vegetation, historical) let determinate. When there are nor vegetation neither historical indices, avalanche paths are determinated from its geomorphologycal characteristics.

Avalanche paths are mapped on 1:10.000 scale coming from an original scale of 1:5.000 from the Institut Cartogràfic de Catalunya (ICC). This is the scale to work on. Afterwards the avalanche maps are published on 1:25.000 scale.

All the information about each avalanche path (morphological description, winter events, return period, photographs, etc..) is not represented on these maps but it is stored in the Avalanche Registry.

MAP OF AVALANCHE PATHS. METHOD

The elaboration of these maps has two basic information sources:

1. Geomorphologycal and vegetation information (Geomorphologycal determination).

2. Witnesses information (human determination).

In the first one, the cartographer interprets the slope characteristics for avalanche release and the avalanche effects (altitude, aspect morphology, and

rugosity of the slope and avalanche effects on vegetation). In the second one, the cartographer collects all the information about winter events (inquiries to ancient people from the mountain villages, people working in winter mountain, etc.).

Afterwards, these two sources will be reflected on the legend of the map. In orange color are represented the avalanche paths determinated by the cartographer and in violet color are represented the avalanche paths from the inquiries.

Then, we can separate three steps in the process to elaborate the map:

1. Geomorphologycal determination. Photointerpretation.

2. Geomorphologycal determination. Field interpretation.

3. Witnesses determination. Population inquiries.

1. Photointerpretation

The photointerpretation consists of the identification of avalanche paths using aerial photographs and stereoscope to watch in a three dimensions view. The photographs used are taken when there is not snow pack and thus it is possible to observe the morphology of the land, the favorable starting zones, the damage on trees and to the forest, etc. In this phase we can watch the whole area affected by each avalanche, and then to represent it.

Depending on its availability and its quality it has been used the 56's, the 74's and the 88's flights with an scale of 1:33.000, 1:18.000 and 1:22.000 respectively.

2. Field Interpretation

This part of the cartography consists on the identification and confirmation of the avalanche paths mapped from aerial photographs. It is carried out during the summer season, when snow cover doesn't exists and then there is better accessibility and better observation of the morphology and other slope characteristics.

It is possible in this case to make detailed observations like the roughness of the terrain, vegetation observations, etc.

The most definitive is the vegetation criteria (when it exists). When there is no vegetation (generally up to 2.000 m asl), the other criteria and the experience of the cartographer will be the valid criteria.

3. Population inquiries

After the field interpretation, the cartographer interviewees to the inhabitants of the zone (if it is possible) and other people who works in the mountain like forestry guards, ski resorts personnel, mountain refuge attendants, etc.

In the inquiry the questions are related to the time when the avalanche falls, kind of avalanche, return period, maximum runout zone, damage, etc.

MAPPING

The classic process to elaborate the avalanche maps consists on:

1. Obtention of the data by the three steps explained before, drawing the avalanche paths on a paper map.

2. Copy of the data on a polyester map to avoid support deformations.

3. Digitizing the data on a digitizing board.

4. Integration of the digitized data in a GIS.

Actually with the GIS it is possible to reduce the process and to elaborate more accurate maps.

The process consists of the direct digitizing on screen. In this process it is possible to have as reference at the same time the topographycal base, the slopes map and the ortophoto. Then it's possible to do the photointerpretation and digitation of the avalanche paths directly on screen and after to get a plot to work on the next steps (field interpretation and population inquiries). In this process it is necessary to use at the same time the stereoscope to watch in a three dimensions view.

Working on screen permits zooming and work in a detailed scale (1:1.000, for example) or to have an overall view (1:50.000, for example). Furthermore the superposition of the information allows a fast analysis of the terrain characterystics.

The steps followed in this method are:

1. Obtention of the data by the three steps explained before. Photointerpretation data drawn and interpretated directly on screen, and field data drawn first on paper and afterwards on screen.

2. Integration of the digitized data in a GIS.

The advantages of this method are:

-Direct digitization on screen, on the topographical base.

-Accuracy on the starting zones because of the superposition of the topographical bases with the slope inclination base.

-Accuracy on the outlines of the track and runout zones because of the superposition of the topographical bases with the ortophoto.

-It avoid graphic random mistakes.

Then we can say that this method is faster and more accurate.

The bases we have used are the next one:

Topographical base: it has been used the 1:5.000 topographical base from the ICC with 5 m contour lines. On this base it is possible to add the planimetry.

slopes map: these maps are obtained from the ICC Digital Elevation Model (DEM) with pixels of 15x15 m. The slope inclination intervals are the next ones (in degrees): 0º-8º 8º-20º, 20º-25º, 25º-35º, 35º-45º, 45º-50º, and more than 50º. The starting outline of the avalanches is determinated from 25 to 45-50 degrees. The range where avalanches begin to decelerate is determinated from the angle interval of 8º-20º and the runout is estimated from this point.

Ortophoto: they come from the ICC 1:25.000 digital ortophotos. They were taken in a flight in summer 1993. The pixel size of the photographs is 1,8x1,8m. It allows to watch kind of vegetation and the effects on vegetation of the avalanches. Then the accuracy on the track and runout outline is very high.

Photogrametric analysis

Working on a digital photogrametric station allows to map the avalanche paths directly in stereoscopy, then the avalanche paths can be drawn on screen and they remain georreferenced on the topographical base.

Winter 95-96 has had quite exceptional avalanche events. In order to test this method it was done a flight for aerial photographs to map exceptional events. The flight was set on a scale of 1:60.000 with a resolution up to 0,9 m. Photographs were taken in black and white because it gives better resolution and in order to realize the contrast of the white of the snow.

The problem has been that the photographs were taken one and a half months after the great events due to the bad weather conditions and the consequent absence of visibility. So it has been only possible to map the avalanches that have destroyed vegetation by the observation of their effects but not the avalanches fallen on the snow, because new snow fell there.

CONCLUSIONS

The superposition of the ortophotos, slopes map, topography and planimetry on screen allows an easy interpretation and a fast analysis of the terrain characteristics.

Digitizing the avalanche paths directly on screen permit a better accuracy in the determination of their limits, it saves steps in the classic process to elaborate the avalanche maps, and so it avoid graphic random mistakes.

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