Avalanche Hazard Mapping in Kazakhstan

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ABSTRACT: Avalanche hazard maps in Kazakhstan are produced in small (≤ 1/500,000), medium (1/100,000 - 1/300,000), and large (> 1/100,000) scales. Avalanche hazard characteristics averaged along river basins are shown on the small scale maps. Avalanche hazard characteristics averaged along river basin sections are shown on the medium scale maps. Avalanche hazard indexes determined for separate avalanche sites are shown on the large scale maps.

KEYWORDS: Avalanche hazard mapping

INTRODUCTION
The map "Regions with Avalanche Hazard in USSR" produced by the specialists of Moscow State University under the guidance of Professor G. Tushinskiy in 1970 can be considered as the first avalanche hazard map produced in Kazakhstan. After 1970 avalanche hazard mapping methods in Kazakhstan were developing in the Kazakhstan Geography Institute under the guidance of I. Severskiy and Victor Blagovechshenskiy. The results of this work became avalanche hazard maps for mountainous areas of Kazakhstan that were published in the Atlas of World Ice and Snow Resources (1997) and in the National Atlas of Kazakhstan Republic (2010). Large number of small and medium scales maps of avalanche hazard and avalanche risk are presented in the Atlas of Natural and Anthropogenic Dangerous and Emergencies Risks in Kazakhstan Republic (2010). In the article they are described the methods of avalanche hazard maps producing that are used in Kazakhstan in nowadays.

SMALL SCALE MAPS
As small scale maps are considered avalanche hazard maps with the scale 1/500,000 and less. They are produced for large mountainous regions with area of more than 1000 km². Territories with avalanche hazards are divided to 5 categories according avalanche hazard degree: low, insignificant, moderate, significant, and high.

On the territories with low avalanche hazard avalanche volumes don't exceed 1000 m³, avalanching is observed less often than once in 100 years; herewith avalanches affict less than 10% of the territories. Avalanche protecting measures are not necessary.

To the territories with non-significant avalanche hazard belong the territories where avalanche volume reaches 10000 m³, avalanches descend less than once a year afflicting less that 50% of the area. For protection it is enough to identify areas with avalanche hazard and make avalanche hazard forecasts.

Moderate avalanche hazard is observed on the territories where avalanche volumes make 10000-50000 m³, avalanches descend several times in a year, and the percentage of avalanche afflicted areas reaches 50%. On such territories it needs to make preventive avalanching.

Significant avalanche hazard is observed on the territories where avalanches volumes reach 50000-100000 m³, avalanches descend several times in a year afflicting up to 75% of the territories. To protect from avalanches it is necessary to build engineering constructions.

On the territories with high avalanche hazard the indexes of avalanche activity are the same as on the territories with significant avalanche hazard, but avalanches afflict more than 75% of the area. Avalanche protecting costs on these territories are so high that they are not usually used in winter time.

To produce small scale avalanche hazard map it is necessary to define the following indexes: avalanche frequency, avalanche volume, and percentage of the areas afflicted by avalanches. To complete this task they are used regional empirically depended indexes of avalanches activity on the factors of avalanches forming: height of snow cover, terrain characteristics, and slopes surface conditions. These dependences are described in the monograph (Severskiy, 1980).

At the first stage it is produced the map of avalanche hazard territories types where are marked the territories with the different valley depth: less than 250 m, 250-500 m, 500-1000
m, and more than 1000 m. Among them they are pointed the areas: with narrow valley bottoms and narrow ridges; with narrow valley bottoms and wide ridges, with wide valley bottoms and narrow ridges, and with wide valley bottoms and wide ridges. Within mountainous area are pointed out territories of high-mountain glacial zone where prevail glacial, rocky and stony slopes, high-mountain periglacial zone where prevail rocky and stony slopes, high-mountain meadow zone with meadow grass slopes, mid-mountain forest and meadow zone with coniferous forests and meadows, low-mountain forest and steppe zone with deciduous forest bushes and steppe grass, and low-mountain steppe zone with bushes and steppe grass.

The map of avalanche hazard territories types is produced using medium scaled topographic maps S 1:100.000, aero photograph or satellite images where it is easy to determine all necessary indexes. Every type of avalanche hazard territory is defined by certain value range of avalanche hazard slopes percentage.

All territories with avalanche hazard are divided by snowiness to low-snowy where average long-term maximum annual value of snow cover height (h_s) don’t exceed 50 cm, moderate-snowy (h_s=50-100 cm) and heavy-snowy (h_s > 100 cm). Area snowiness is determined according the representational meteorological station data or regional snowiness dependence on territory altitude (Severskiy, 1983). Avalanche frequency is evaluated according territory snowiness. In the areas with low snowiness avalanches repeat less than once in 10 years, in the areas with moderate snowiness avalanches repeat each year, and in the areas with heavy snowiness avalanches descend several times in a year.

Avalanche volumes depend on snow cover height, valley depth, and slopes surface conditions (Severskiy, 1983; Blagovechenskiy, 1991). By this procedure there were composed small scaled maps of avalanche hazard on all the mountainous areas of Kazakhstan. The maps were published in the National Atlas of Kazakhstan republic (National, 2010), and Emergency Atlas (Atlas, 2010). These maps are used while working out the plan of mountainous territories development.

MEDIUM SCALE MAPS

Medium scale maps have scale of 1:300.000 to 1:100.000. They are made for the mountain areas from 100 to 1000 km². Map’s scale allows to show avalanche hazard characteristics averaged along groups of avalanche sites.

As on the small scale maps, on medium scale maps are pointed out 5 categories of avalanche hazard but there are used other criteria of avalanche hazard degree (Table). While composing medium scale avalanche hazard maps determining snow cover height it is necessary to consider not only slope altitude but also slope orientation. Such dependences were obtained by I. Severskiy for all mountainous areas of Kazakhstan (Severskiy, 1983). Steepness, height, and character of slope surface are determined with topographical map. Avalanche volumes are determined by snow cover height, and slopes height and slope morphology. Percentage avalanche hazardous sites is determined by slopes morphology and slopes surface condition.

The Table: Avalanche activity indexes with the different avalanche hazard degrees

<table>
<thead>
<tr>
<th>Avalanche hazard degree</th>
<th>Avalanche volume, (10^3 \text{m}^3)</th>
<th>Avalanche frequency, 1/year</th>
<th>Avalanche extension, % of the affected territory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt;0.1</td>
<td>1/10</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Insignificant</td>
<td>0.1-1</td>
<td>1/10-1</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Moderate</td>
<td>1-10</td>
<td>&gt;1</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Significant</td>
<td>1-10</td>
<td>&gt;1</td>
<td>&gt;50</td>
</tr>
<tr>
<td>High</td>
<td>&gt;10</td>
<td>&gt;1</td>
<td>&gt;50</td>
</tr>
</tbody>
</table>

Medium scale maps of avalanche hazard were also produced for all mountainous areas of Kazakhstan. They were published in the Emergency Atlas (Emergency Atlas, 2010). These maps are used to choose the areas for infrastructure objects, residential areas, roads and lines of communication.

LARGE SCALE MAPS

Large scale maps are composed with the scales more than 1:50 000 for the territories less than 100 km². There are shown the borders and characteristics of avalanche hazards for separate avalanche sites and sometimes even parts (for example runout zone) of them. The most important characteristics are avalanche frequency and of avalanche distances.

These characteristics are the most exactly determined according the data of long term avalanches researches. Without such data the avalanche parameters are determined by the methods of mathematical simulation. In our works we used two-parameter model. We determined friction and turbulence resistance coefficients within this model according the data of avalanche field researches in the Ile Alatau. The possibilities of mathematical simulations using being dimensioned by field researches are examined in the work (M. Eglit, 2002).
Avalanche path length frequency within mathematical simulation is determined by avalanche volumes frequency in the certain avalanche site. Avalanches volumes frequency is determined by the area of avalanche starting zone and the frequency of snow cover height depending on altitude and orientation of the avalanche starting zone.

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REFERENCES