Changes of the avalanche cadastre in the Czech part of the Giant Mts.

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ABSTRACT. Giant Mts. are the highest and the only mountain range of the Czech Republic which features considerable avalanche activity. There are at average 22 avalanches events on 47 avalanche paths in a year. Human colonisation and subsequent exploitation during the 16th and 17th centuries led to the growth of treeless area which resulted in an increase of avalanche paths. Reforestation in the course of the 18th to 20th centuries has decreased the risk of spread of avalanches. Since 1980 the Giant Mts. have been strongly afflicted with emissions. Norway spruce monocultures have started to die off, the avalanche cadastre has risen again. Partial analyses reveals that the intensive avalanche activity has been (even in the past) bounded to extraordinary climate conditions and thus the growth of the avalanche cadastre can not be related exclusively to the decline of protective function of the forest. Natural development of mountain slopes should not be omitted as this process includes both snow avalanches and debris.

NATURE CONDITIONS

The Giant Mts. (called Krkonose / Karkonosze in the Czech and Polish, respectively) form a part of the Central European branch of the Hercynian mountain range - in fact its highest part called the High Sudetes. They constitute the border mountain range between the Czech Republic and Poland, they reach the altitude of 1602 m and unlike the neighbouring middle-mountains of the Central Europe they markedly surpass the alpine timberline over some 15 km. Because of their extraordinary nature values the Giant Mts. have been protected as national parks on the Polish and the Czech sides since 1959 and 1963, respectively. In 1992 the whole area was declared a bilateral biosphere reserve.

Development of the Giant Mts. relief was vastly influenced by weathering and denudation of crystalline metamorphic rock and granite in the warm and humid climate of Mesozoic Era, renewed fluvial erosion in the course of the Tertiary and by Pleistocene glaciation. The west-east orientation of main windward valleys, two summit plateaux at the high of 1340 and 1400 m a.s.l. and a fan of a leeward slopes of glacial cirques (anemo-orographic systems sensu Jenik, 1961) present characteristic traits of the Giant Mts. Geographic position of the Giant Mts. at the southern margin of German - Polish lowlands and the west-east orientation of main valleys predispose attacks of strong and cool northern winds as well as prevailing western ocean current on the summit areas. The climate of the alpine area is consequently quite severe; average year temperature is 0 to 1 °C, precipitation rate is 1500 mm, snow cover lasts from November to May and reaches average thickness of 190 cm, avalanche activity is unusually frequent for the middle-mountains (47 avalanche paths are known on the Czech and another 36 ones on the Polish sides). From the forestry typology point of view forest stands of the 6 altitudinal vegetative stages are developed (dwarf pine zone including area of arctic-alpine tundra /sensu Soukupova et al., 1995/, spruce, beech-spruce, spruce-beech and fir-beech zones).

SETTLEMENT AND AVALANCHES

The Giant Mts. are really densely populated, there are numerous mountain villages, tourist centres, mountain chalets and rich network of tourist paths which often cross even avalanche fields. Each year as many as 5 million tourists arrive to visit the Giant Mts. The systematic settlement of the Giant Mts. began in the 16th century as a result of the rise of mining and chalet farming. Natural disasters such as snow avalanches, debris or floods gradually made the inhabitants abandon the endangered areas. Nowadays all the chalets are accessible from various directions which enables to avoid avalanche fields. A number of winter accidents that happened (67 persons died in avalanche events during 300 years) led to the establishment of the Mountain Rescue Service in 1934. Its involvement in snow observation and avalanche control has been initiated in 1954,. since 1962 the Service has dealt with regular weekly monitoring of avalanche conditions,

recording of all avalanche events and their description based upon international classification (Spusta, Jenik, Kocianova, Sprava KRNAP Vrchlabi, 1997). If there is a danger of an avalanche event, the corresponding avalanche fields are immediately closed to public attendance. In the last 10 years the avalanche caused the death of 1 person only.

AVALANCHE CADASTRE AND ITS CHANGES

In 1962-1997 there were 698 avalanche events on the Czech side. About 75% of avalanche paths coincide with locations of Pleistocene glaciers and nivation niches. Avalanches are of small or medium sizes with maximum length of 1500 m and width of 250 m which is due to the relief of the mountain range. Zones of avalanche origin take place on small area (only 15x4 km) and are mostly situated above the timberline or along the upper timberline (1250 - 1602 m a.s.l, /Jenik, J. et Lokvenc, T., 1962/). Avalanche paths climb up in to the montane zone to the maximum of 870 m which means they reach the Norway spruce -beech vegetative zone too.

The avalanche activity is assumed in the Giant Mts. since the end of Tertiary in connection with gradual cooling of the climate. According to written records (the first mention comes of 1456) there were major avalanche events in the 16th and 17th centuries - colonisation and subsequent exploitation (mining, timber-cutting, farming) led to the growth of treeless area which resulted into the increase of avalanche paths. Reforestation of mountain slopes in the course of 18 th -20 th centuries has decreased the risk of spread of avalanches. However, mostly non-native seedlings (imported from the Alps) used for the reforestation were less resistant to stress than the native population. Since the 1980 the Giant Mts. region has been a part of the so-called "black triangle" in Central Europe that is the area strongly afflicted with emissions. The action of wide spectrum of emission substances leads to dying off of forest in a great scale, to its cutting and subsequent disaster caused by the insects.

When the evaluation of the avalanche cadastre was carried out in 1989 (Vrba et Spusta, 1991) it was find-out that roughly 1/3 of all the avalanche paths enlarged and extended. These changes were put into the relation with dying-off of forest as a result of emissions and with the decline of its function as a protection barrier. The first apparent changes of Norway spruce complexes were revealed in 1977 (Vacek, Podrazsky, 1995). Physiological changes of needles already appear when the SO_2 concentrations in air reach the level of 15μg/m^3 (Materna, 1979). Within 1984 -90 the measurements conducted on the summit area of the Giant Mts. (Schwarz, Sprava KRNAP Vrchlabi,m.s., 1990) showed the average year values from 10,3 to 26,7μg SO_2/m^3 of air with the highest value of 160,34μg SO_2/m^3 of air. The decrease of emission production of power stations in the former German Democratic Republic and in the Czech Republic since 1991 is the reason why the contemporary state of the air in the Giant Mts. can be denoted as emission free (Vacek, Podrazsky, 1995).

More detailed assessment of avalanche cadastre from the monitored period of 1962/63 - 1996/97 shows the following facts: The avalanche cadastre has risen again about 1/5 up to contemporary 450 ha which equals about 10% of the core area of the Krkonose National Park. In total the changes of 18 avalanche paths were recorded (fig. 1.), 26 ha of forest were destroyed. In nine cases the first changes (in the sense of the spread and extension) happened before 1977/78, i.e. before the main emission action. After 1977/78 four new paths turned out (two of them had connection with debris) and next four paths were indicated as a short snow motion with the connection of debris as well. Most of changes took place in years which higher avalanche activity occurred (more than 30 avalanche events in a winter season) - there are 1969/70, 1975/76, 1986/87, 1987/88 or in connection with a sudden change of climate conditions (great amount of now snow, temperature collapses, windstorm) which resulted in general short growth of avalanche activity (11 - 34 events in a month) - 1962/63, 1964/65, 1967/68, 1970/71, 1981/82, 1985/86, 1994/95 (Spusta, Sprava KRNAP Vrchlabi,m.s., 1996).

The changes are not concentrated in glacial cirques where avalanche paths are predisposed with regard to rocky slopes but in two young erosion valleys with forested slopes (avalanche paths no. 9-19). Important trait of this area is a high number of debris. In the line 2 km long there are 12 and 65 debris, respectively which coincide with avalanche paths quite often. The presence of debris confirms the existence of natural dynamic development of slopes with great relief energy (Pilous, 1977). Even though it is evident, that the process of dying-off forest increases the possibility of avalanche events, but this phenomenon is not the only cause of avalanche cadastre changes. Historical records mention big avalanches with devastating effects in 1819,1827,1844,1887,1956 in connection with high snow precipitation. The year of 1956 is especially important because of the forests were not devastated neither by the extreme exploitation nor emissions nor the insects. The avalanche events ran on 8 March 1956 destroyed 12 ha of forest (Vrba, 1969). That day the biggest event occurred on a newly developed avalanche path on a slope covered by 150 years old forest.

BENEFITS OF THE AVALANCHES

In the course of the Postglacial period, including the climatic optimum suitable for expansion of forest, the snow avalanches continually prevented the invasion of forest trees and thus secured the survival of rare arctic and alpine organism. Also, various rare lowland non-.forest species have found their refuge on the avalanche tracks. The avalanche-prone slopes and cirques served also as cradles of new species, and thus became remarkable centres of biotic micro-evolution. Several new species of plants have been first identified for science in populations restricted to small areas of the active avalanche fields. As the present

time, a consensus exists that avalanche activity in the uppermost altitudes of the Giant Mts. should not be human-controlled and that the active avalanche fields represent the most valuable sanctuaries in the national parks (Jenik 1961, Spusta, Jenik, Kocianova, Sprava KRNAP Vrchlabi, m.s.,1997).

CONCLUSION

Avalanches constitute a natural and integral part of the Giant Mts. nature. The changes of the avalanche cadastre primarily result from the influence of natural factors (climate conditions or relief development) and partly also from the influence of human activities (deforestation).

In the last 20 years forests of the Giant Mts. have dyed-off on a great scale. The process was caused by emissions and decreased the ability of forest to act as avalanche barrier. Although the air situation has been characterised as emissions free since 1991, long-lasting development of consequences of this ecological disaster has been expected, there might occur even some bigger subsequent changes of avalanche cadastre..

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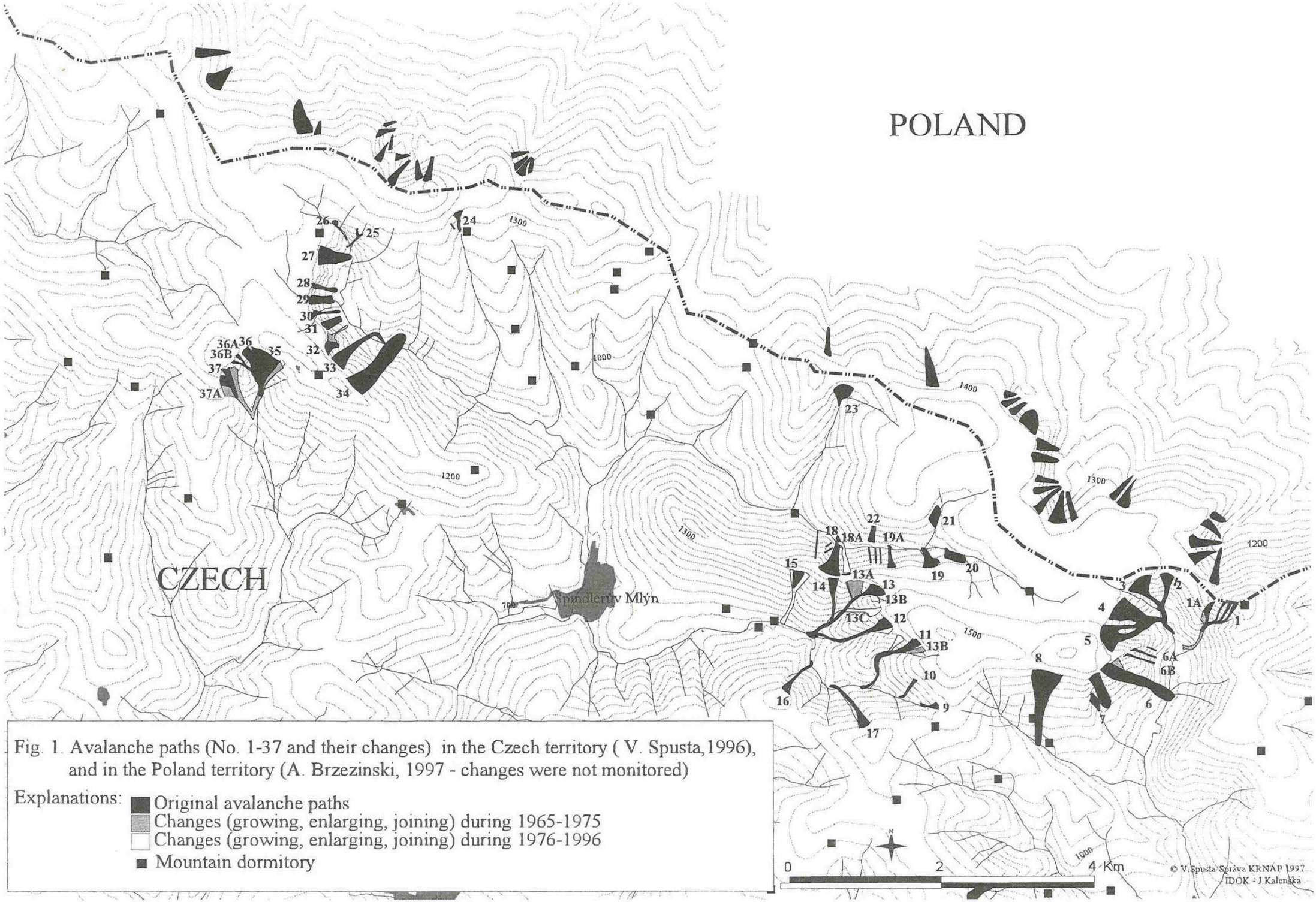

Fig. 1. Avalanche paths (No. 1-37 and their changes) in the Czech territory (V. Spusta, 1996), and in the Poland territory (A. Brzezinski, 1997 - changes were not monitored)

Explanations:
- Original avalanche paths
- Changes (growing, enlarging, joining) during 1965-1975
- Changes (growing, enlarging, joining) during 1976-1996
- Mountain dormitory