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*Leszek Litwin**

A STUDY OF PERENNIAL SNOW PATCHES IN THE SLOVAK HIGH TATRAS - PRELIMINARY RESULTS

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The first inventory of permanent snow patches in the Slovakian High Tatras has been completed. 25 snow/ice masses assumed to be permanent has been listed and described. Detailed characteristics and fluctuations of the largest glacieret in the Tatras which is situated in the Medená Valley in the slopes of the Lomnický Peak (2632 m a.s.l.) is presented. The glacieret in Medená Valley is very sensitive to meteorological conditions as observed in 1992-1994. General reduction of area and thickness of the patches are observed.

Key words: perrenial snow patches, glacierets, Slowak High Tatras

INTRODUCTION

The presence of perrenial snow patches in the Tatra Mts has attracted the researches of its Alpine environment for many years. In southern Tatras, Ksandr (1954), Vitásek (1956), Šebesta (1971) and Lukniš (1973), paid some attention to this problems. Also Polish researchers contributed to the general knowledge of the contemporary glaciation in the Slovak High Tatras. Among them, Gadomski (1925, 1926) carried out the first scientific observations of these forms. The investigations were mainly carried out on the largest glacieret in the Tatras, i.e. Medeny glacieret (in the Medená Basin). Although the investigation of snow patches first started in the Slovak Tatras, those carried out in the Polish Tatras were more comprehensive and detailed (Milata 1949, Wdowiak 1959, 1961, 1969, Kłapowa 1980, Kłapa 1966, 1968 Wiśliński 1985, 1986, 1993).

*University of Silesia, Faculty of Earth Sciences, Department of Geomorphology, Bndzinska 60, 41-200 Sosnowiec, Poland

This paper presents the results of the investigation of perennial snow patches in the Slovak High Tatras. The fieldwork studies include:

- detailed observations of the glacieret in the Medená Basin at the foot of Lomnický štít and snow patches in the adjacent Veľká Zmrzlá Valley;
- listing of the snow patches in the whole chain of High Tatras.

The aim of this research was to supplement the listing of snow patches which occur in the Tatra Mountains. The listing of snow patches present in Polish part of the High Tatras was completed by Wislinski (1993) according to the instructions of the World Glacial Monitoring Service. It was, therefore, necessary, to introduce such system inventory in the Slovak part of this mountains.

Another problem shown in this paper concerns the relationship between the fluctuation of the perennial snow patches and glacierets and the fluctuation of meteorological conditions. This research was mainly carried out on the glacieret in the Medená Basin. These were the first observations of the state of the perennial snow patches and glacierets in the Slovak High Tatras ever carried out.

CLASSIFICATION OF THE PERENNIAL SNOW PATCHES AND GLACIERETS

Generally, 25 perennial snow patches were determined basing on field observations, analysis of meteorological data and glaciological literature. Their features are shown in Tab. 1. Apart from the snow patches, some small snow fields were also observed. These, however, were not classified because they did not comply the requirements of the listing.

All the snow patches show some common features. They are present at the altitude from 1780 to about 2500 m a.s.l. and occur within three climatic vertical zones: very cold, moderately cold and cold (Tab. 2). Some of the snow patches occur in two or even three vertical climatic zones (glacieret in Medená Basin).

It is assumed that the lower limit of the lowest snow patch (no. 0141 in the Kačia Valley) reflects the location of the local orographic equilibrium line. In Polish part of the Tatra Mountains, the snow patches situated at the lowest atlitude occur at 1530 m a.s.l. (after Prokop 1992).

The observed snow patches occur mainly in concave landforms such as depressions at the foots of steep slopes, bottoms of valley and gullies. Such location influences specific microclimatic conditions and way of snow accumulation, which, in turn, enable snow patches to be preserved during summer.

Concave landforms and depressions where snow patches are located show lower average annual air temperature than convex landforms which are located at the same altitude (Hess 1965). In the depressions, the air circulation is different than that on the open flat area or mountain summits. Generally, it is less ventilated in the first case. This leads to development of stagnant cold air which favours snow patches to survive during the ablation periods. Inversion of temperatures which is observed mainly during winters (but also in springs and autumns) shows similar influence (Hess 1965).

Most of the observed snow patches face N, NW and NE. This influences suitable insolation conditions for development and preservation of snow patches. This way snow patches occur within a zone of permanent shade during large part of the ablation season. Only 5 snow patches observed face different directions (without N component).

Tab. 1. Selected typical features of permanent snow patches

Number of snow patch	Exposition	Inclination	Altitude of the lower part of the snow patch (m a. s. l.)	Size of the snow patch
0131	NE	–	2150	average
0132	N	–	2200	big
0133	N	–	2100	big
0134	NW	–	2150	big
0141	NE	–	1780	average
0142	NW	–	2000	big
0143	N	–	2000	big
0161	NW	$30 - 35^0$	2100	average
0271	NW	–	–	average
0281	NW	–	–	average
0331	NW	–	2000	average
0351	E*	31^0*	2200*	average
0352	N*	30^0*	2160*	average
0353	NE	*20^0*	2065*	small
0361	NE**	34^0**	1990**	big
0511	W	45^0	–	small
0521	NE	35^0	2000	average
0522	W	35^0	2050	average
0701	NE	25^0	2050	small
0901	SW	–	2250	average
1221	NE	–	2000	average
1241	N	–	2250	small
1261	NW	–	2100	average
1731	SW	–	2200	average
1741	N	–	2000	big

* - according to Ziob (1995)
** - according to Zagól (1995)

The inclination of the snow patches is, generally, in the range 30-35°. In case of larger forms, it is difficult to determine precisely the inclination of the whole patch. It depends on local morphology of the slope. The smallest inclination - about 20° - was determined at the snow patch no. 0353 in the Veľká Zmrzlá Valley. More detailed determination of the snow patch inclination was limited because not all the snow patches were surveyed in details. The inclination of about 30° together with the situation that a slope faces N, NE or NW favours the preservation of snow patches because the amount of direct solar radiation which reaches the active layer is limited. The occurrence of the snow patches in the depressions at the foot of steep slopes, in concave parts of the landform and in the gullies shows predominant ways of snow accumulation which enable snow patches to survive warm season. The spilling and avalanche accumulation and also aeolian accumulation predominate among them. The aeolian accumulation is considerably important in the depressions which are situated at the axes of the most frequent air currents. Especially favourable wind exposition is that associated with the direction of wet air mass inflows, namely W, N and NW which bring abundance of snow falls. Aeolian accumulation is also important in terms of re-blown snow from convex to concave landforms.

Tab. 2. Selected features of vertical climatic zones (after Hess 1965)

Type of the climate	Zone	Average altitude of the limits (m a.s.l.)	Average annual temp. (°C)	Average annual sum of precipitation (mm)	Average number of days with snow cover	Average number of cloudy days	Average number of frosty days
Nival	cold	2665	-4,0	1625	290	140	200
Nival-pluvial	moderately cold*	2200	-2,0	1750	250	160	165
	very cool	1850 (1670)	0,0	1800	215	165	135
	cool	1550 (1400)	2,0	1600	180	145	95
Pluvial-nival	moderately cool	1100	4,0	1400	140	160	70
	moderately warm	700 250	6,0 8,0	1000 800	105 65	175 135	50 35

* - climatic equilibrium line

THE METHODS OF INVESTIGATIONS

A detailed investigation of the glacieret in the Medená Basin has been carried out since 1992. Every year, at the end of the ablation period, photogrammetric photographs of the glacieret have been taken (Kolondra and Jania) and then ploted into a map at the scale 1:2000 (L. Kolondra). The photographs were used to determine the limits and area of the glacieret. These data were compared then with meteorological data recorded at the meteorological station at Lomnický Peak (2632 m a.s.l.). The latter data concern both the years when glaciological observations were carried out (1992-1994) and also the period 1985-1994. This comparison has enabled to investigate the fluctuations of the glacieret in the Medená Basin in the period 1992-1994 and to determine the relationship between the fluctuation of the glacieret and meteorological conditions.

Additionally, a detailed surveying at a scale 1:1000 of the selected snow patches in the Veľká Zmrzlá Valley was carried out. These data were used to determine in detail the size and area of snow patches at the end of the summer 1994 (Ziob 1995).

In the September 1993 and 1994, the observation and listing of snow patches which were assumed to be permanent were carried out. An attempt was made to classify them and the instructions of the IASH (World Glacial Monitoring Service, 1988) became the basis of this classification. According to these instructions, the area studied was divided into basic hydrological basins (Fig. 1) and numbered. Then, the listed snow patches were code numbered (Fig. 2). Additionally, basic features of the snow patches were classified according to Kałapa (1966). All the observations were carried out at the end of the ablation season, thus, a presumable minimal limits of the perennial snow patches in 1994 were noted.

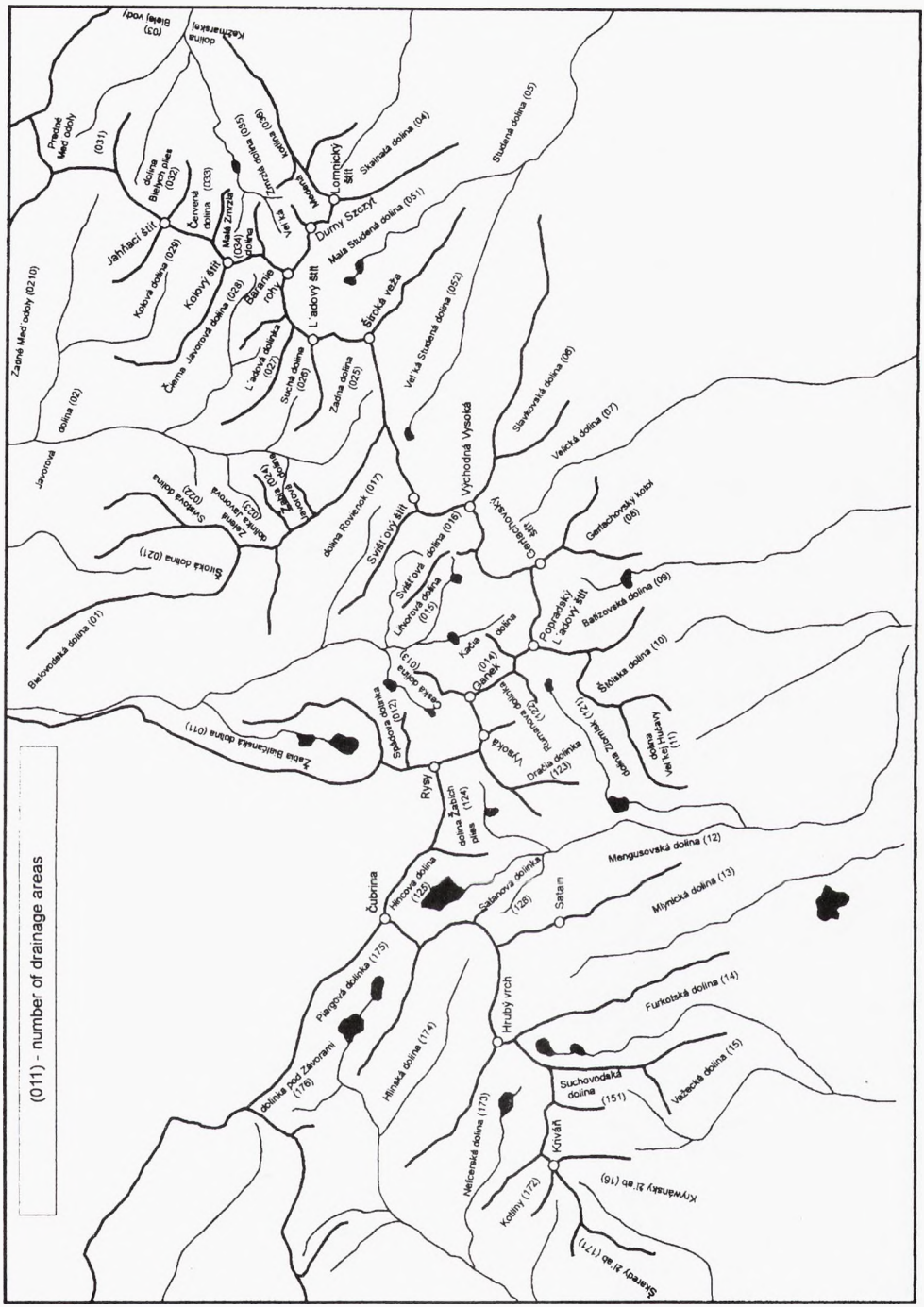

Fig. 1. Numbering of drainage areas in the area studied.

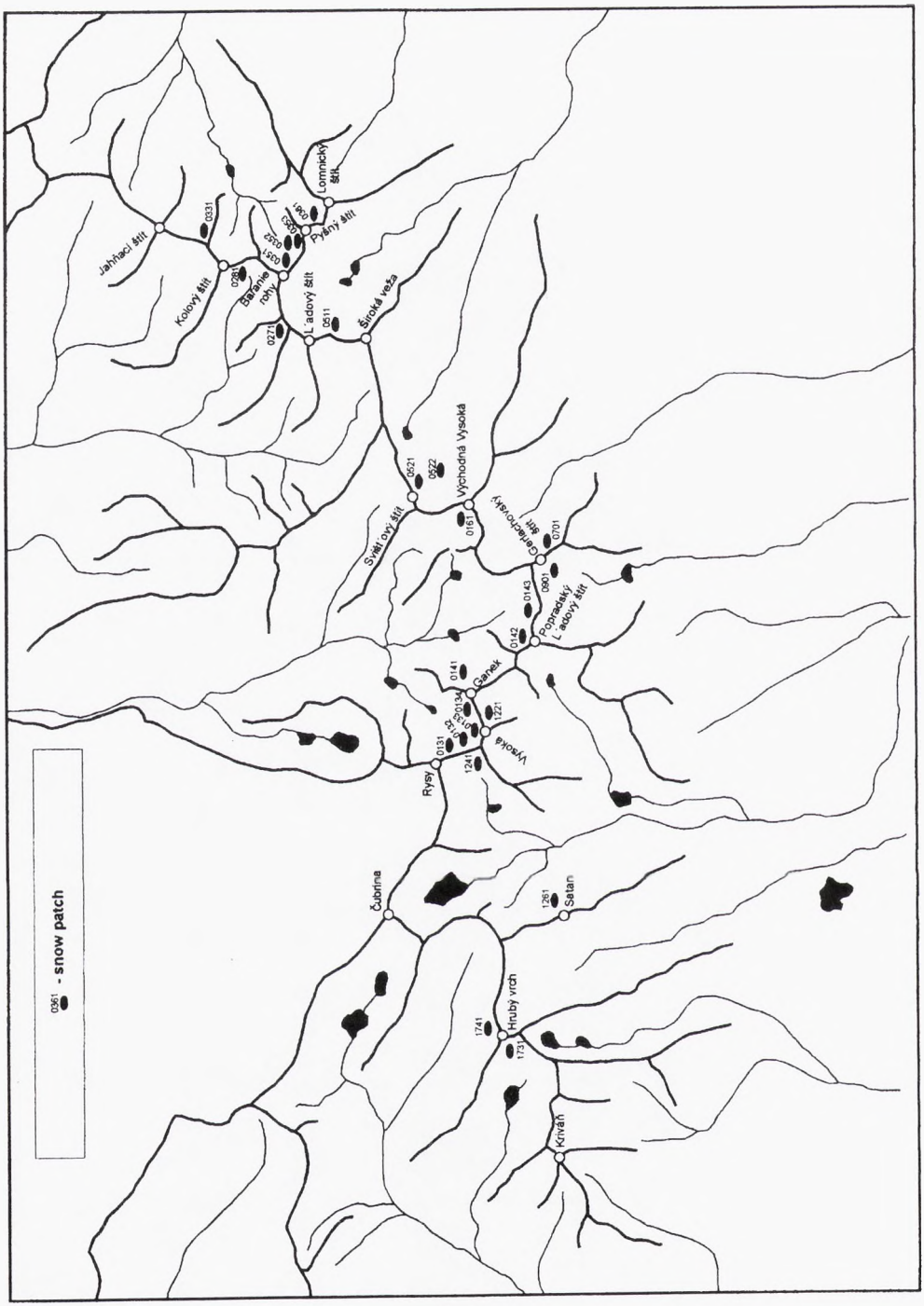

Fig. 2. Location of perennial snow patches in the Slovak high Tatras.

FLUCTUATIONS OF THE GLACIERET IN MEDENÁ BASIN AS COMPARED WITH METEOROLOGICAL CONDITIONS

At the end of the summers 1992, 1993 and 1994, the photogrammetric photographs of the glacieret in Medená Basin were taken from the threshold of the Červené Lake. Basing on terrafotogrammetric maps, the areas of the glacieret from the separate years were compared (Zagól 1995). The most important data are shown in Tab. 3.

Tab. 3. Fluctuations area of the glacieret in the Medená Valley

Date	Area of the glacieret
25th of August 1992	3,4 ha (0,034 km^2)
18th of September 1993	5,0 ha (0,05 km^2)
10th of September 1994	3,2 ha (0,032 km^2)

The area of the glacieret in Medená Basin was the largest in 1993. The average annual temperature of this year was similar to the average from the period 1985-1994; the average summer temperature of 1993 was the lowest in this period and precipitation was the smallest as well.

The total number of days with snow fall in 1993 against the general number of days with precipitation was similar to the average from the period 1985-1994. The smallest areas of the glacieret in Medená Basin was observed in 1994. The average air temperature in this year was 1^{o} C higher than the average temperature from the period 1985-1994. The average summer temperature was higher by 2.2^{o} C. At the same time, the precipitation in this year was 500 mm larger than the average precipitation from the period 1985-1994 and the number of days with snow fall in 1993 against the general number of days with precipitation was similar to the average from the period 1985-1994 and to the average annual values from 1992 and 1993.

The comparison of the meteorological data recorded at the high-mountain meteorological station at Lomnický Peak (2632 m a.s.l.) and changes of the glacieret's area shows that the fluctuations of the glacieret in Medená Basin are mainly influenced by fluctuations of average summer air temperature (Tab. 4).

Tab. 4. Average air temperatures of summer
(meteorological station at the Lomnický Peak, 2632 m. a. s. l.)

Years	Average temperature °C
1992	5,0
1993	2,2
1994	5,6
1985-94	3,4

CONCLUSIONS

The field investigation suggests that the location of snow patches and glacierets in concave landforms and their favourable solar and wind exposition is the basic condition for snow patches to originate and to be preserved throughout the summer. This

may be the base to determine such places, where snow patches should, theoretically, occur. Also a cooling influence of a snow patch which is situated in the depression on the microclimate of the adjacent local area should be emphasised. This is assumed to be a positive factor in preservation of snow patches during summer.

The analysis of the meteorological data from the period 1985-1994 shows that the limit of the snow patches was probably the smallest in 1994.

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Fig. 3. Glacieret in the Medená Valley (8.9.1994, foto L. Litwin).

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ŠTÚDIUM ZVYŠKOV TRVALÉHO SNEHU V SLOVENSKEJ ČASTI VYSOKÝCH TATIER - PREDBEŽNÉ VÝSLEDKY

Vedecký výskum permanentných snehových polí vo Vysokých Tatrách sa začal v dvadsiatych rokoch tohto storočia. Prvé správy obsahovali len kvalitatívne črty týchto polí bez kvantitatívnych

Fig. 4. Perennial snow patches in the Veľka Zmrzlá Valley (8.9.1994, foto L. Litwin).

Fig. 5. Perennial snow patches in the Červená Valley (6.9.1994, foto L. Litwin).

Fig. 6. Perennial snow patches in the Veľka Studená Valley (4.9.1994, foto L. Litwin).

Fig. 7. Perennial snow patches in the Velická Valley (2.9.1994, foto L. Litwin).

údajov. Odvtedy sa robili štúdie rozmiestnenia, výskytu, veľkosti a zachovávania sa polí počas teplých období a typu ablácie. Na poľskej časti Tatier sa od štyridsiatych rokov robili podrobné štúdie permanentných snehových polí a ich katalogizácia vo vybraných údoliach. Menej pozornosti sa venovalo snehovým poliam na slovenskej strane, okrem visutého ľadovca v Medenej doline, ktorý je najväčší v celom pohorí.

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Tab. 1. Vybrané typické črty permanentných snehových polí.
Tab. 2. Vybrané črty vertikálnych klimatických zón (podľa Hessa, 1965).
Tab. 3. Oblasť fluktuácie visutého ľadovca v Medenej doline.
Tab. 4. Priemerné letné teploty vzduchu (meteorologická stanica na Lomnickom štíte, 2632 m nad morom).

Obr. 1. Číslovanie povodí v študovanej oblasti
Obr. 2. Umiestnenie permanentných snehových poli v slovenských Vysokých Tatrách.
Obr. 3. Visutý ľadovec v Medenej doline (8. sept. 1994, foto Litwin)
Obr. 4. Permanentné snehové polia vo Veľkej Zmrzlej doline (8. sept. 1994, foto Litwin)
Obr. 5. Permanentné snehové polia v Červenej doline (6. sept. 1994, foto Litwin)
Obr. 6. Permanentné snehové polia vo Veľkej studenej doline (4. sept. 1994, foto Litwin)
Obr. 7. Permanentné snehové polia vo Velickej doline (2. sept. 1994, foto Litwin)

Translated by H. C o n t r e r a s o v á