INTENSITY OF SOME CONTEMPORANEOUS MORPHOGENETIC PROCESSES ABOVE THE TIMBERLINE IN THE WEST CARPATHIANS

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1. INTRODUCTION

Only on the basic long-term exact measurements in the field a good image on a rate of morphogenetic processes may be obtained. It is very complicated task because direct measurements are very difficult in high mountains. Difficulties are connected also with a separation of influencing of individual morphogenetic processes. Therefore there are relatively few data from high - mountain terrain of the West Carpathians in contradistinction to data on rainfall erosion of hilly country of both, Czechoslovakia and Poland where the mountains of the West Carpathians are occurred.

The data about an intensity of morphogenetic processes above the timberline were obtained by means of different methods, mostly by the direct research methods (see T. Gerlach 1964, 1977, T. Gerlach, L. Kaszowski, A. Kotarba 1978, M. Kłapa 1970, A. Kotarba 1970, 1976, A. Kotarba et al. 1979, R. Midriak 1972, 1979, D. Zachar 1970). As the data are collected mostly from short time (within 10 years) it is necessary to consider them as the data of orientation. The task of further research will be to continue in collection of the data for their higher exactness.

2. RESULTS OF RESEARCH

2.1 Portion of different morphogenetic processes in modelling of sllopes above the timberline

Forms of relief modelling above the timberline have a polygenetic character mostly. For this reason an objective determination of the portion of separate morphogenetic processes in creation of those forms is very difficult. In high mountains of the West Carpathians almost totally complex long-term stationary measurements are missing, too. Only data from territory of the Hala Gąsienicowa in Polish Tatra Mts. (see M. Kłapa 1975) are the exception to the above mentioned rule.

In case that we deduce from acting 12 basic morphogenetic processes according to M. Kłapa's calendar of the morphogenetic processes, we can constitute for conditions of the subalpine belt (e.g. a very cool climatic belt within 1400 to 1850 m a.s.l.) this mean representation of the processes:

- gelivation and rockfall - during 30 and more % of the days in the year,
- frost heaving of soil - during 20 to 30 % of days in the year,
- physical weathering, suffosion, needle ice, deflation, runn-off along with washing, nivation around snow patches, abrading and mass transportation by snow avalanches - during 10 to 20 % of days in the year,
- soil mass creeping and solifluction - during 5 to 10 % of days in the year.

In above mentioned interpretation a time portion of the morphogenetic processes (that are conditioned by climate) is given. The sequence of duration of the morphogenetic processes can be changed in dependence on altitude as well as climatic conditions of single high mountains in the West Carpathians. From the point of view of climate - morphogenetic seasons (after M. Kłapa 1975) there is also a different sequence of the morphogenetic processes in their duration within the niveopluvial, pluvial, pluvionival and nival periods.

As regards a shape effect (relief-formating effect), it can be stated that nearly all time-prevailing morphogenetic processes in area above the timberline (e.g. frost heaving of soil, acting of needle ice, deflation, gelivation with rockfalls etc.) are preparing conditions to intensive destruction of slope surfaces during one or many years. This destruction, however, along with enormous mass transportation is coming in the course of catastrophic rainstorms. The heavy rains of summer, with intensity of 100 mm per day (or more), are the most important factor because they cause intensive erosion processes as well as mass movements. A frequency of these events is every three years (M. Kłapa 1975).

2.2 Intensity of contemporaneous slope modelling processes above the timberline

In Table 1 a review of data concerning a rate of some contemporaneous morphogenetic processes in the subalpine and alpine belts of high mountains in the West Carpathians is given by individual authors. The data are classified after primary groups of geomorphic phenomena to appear a portion of single processes in intensity of slope surface retreat.

Table 1

Rate of contemporaneous morphogenetic processes above the timberline in high mountains of the West Carpathians in both the Czechoslovak and Polish territory (a short version of R. Midriak's one, 1979)

Geomorphic phenomenon	Morphogenetic process	Intensity (rate) of the process	References
1	2	3	4
1. Erosion processes			
1.1. Water erosion	Retreat and/or lowering of slope surface		
1.1.1. Rain wash	- " -	0.02 to 12.85 mm per annum	J.Brański (ex T.Gerlach 1976), R.Midriak 1979

1st contin. of Tab. 1

1	2	3	4
1.1.2. Linear erosion	Retreat and/or lowering of slope surface	17.40 $mm.year^{-1}$	R. Midriak 1979
Vertical erosion of touristic traces	- " -	2.00 to 3.29 cm during one summer - autumn season	- " -
1.2. Snow erosion - nivation	Retreat of nivation hollow periphery	1 to 19 cm per annum	A.Kotarba 1976, R.Midriak 1979
1.3. Wind erosion	Retreat of slope surface	0.000033 to 0.5 $mm.year^{-1}$	- " -
	Retreat of eolic hollow periphery	2.28 to 3.38 cm per annum	- " -
2. Gravitation phenomena			
2.1. Rockfall	Rockwall retreat	0.01 to 3.00 mm per annum	A.Kotarba 1972a, 1976, R.Midriak 1972, 1979
	Rock matter accumulated on talus slope	0.26 to 13.00 mm per annum	A.Kotarba 1972a, R.Midriak 1979
2.2. Creeping	Down-slope movement of debris cover		
	- loose scree	10 to 37 cm per annum	A. Kotarba 1976
	Lowering of slope surface	0.36 $mm.year^{-1}$	A.Dobija 1973
	Movement of soil mantle with grass	0.18 to 1.70 cm per annum	A. Kotarba 1976, 1977
	Creeping of ploughing blocks	0.14 to 3.25 cm per annum	A. Kotarba 1976
2.3. Snow dirty avalanches	Break down of soil mass	15 to 35 cm at once	L. Milan 1975
2.4. Debris avalanches	- " -	55 $mm.year^{-1}$	V. Zelina 1964
2.5. Surface layer movement of scree	Down-slope movement	0.59 to 0.66 m (max. 21 m) per annum	R. Midriak 1972
3. Cryogenic phenomena			
3.1. Gelivation	(see the retreat of rockwalls)		
3.2. Needle ice	Displacement of soil material	0.5 to 7.0 cm per annum	T.Gerlach 1964, M. Kłapa 1975
	Number of layers:loosening of layer of soil material by once regelation cycle	1:0.48 to 1.06 mm 2:3.96 mm 3:3.64 to 6.62 mm	R. Midriak 1972, 1974, 1979

2nd contin. of Tab. 1

1	2	3	4
3.3. Frost heaving of soil - on the bare surface - on surface with plants	Vertical movements - max.heaving:max. amplitude - -	 94:125 mm 8:18 mm	T. Gerlach 1972, M.Kłapa 1975, R. Midriak 1974, 1975, 1979
3.4. Solifluction (bound)	Down-slope movements of soil mantle with grass	0.14 $cm.year^{-1}$	A. Kotarba 1976
4. Karst phenomena	Retreat and/or lowering of slope surface (chemical denudation)	0.04 $mm.year^{-1}$	A. Kotarba 1971

In accordance with data in Table 1 we can state that erosion phenomena (especially rainfall erosion processes) are the most important processes for a contemporary development of slopes in the subalpine and alpine belts on smooth relief with predominant of alpine meadows in the West Carpathians. Because the area of rainfall erosion action is the most extended (the rate of slope retreat by this process is mostly from tenth to some millimetres), water erosion processes play the important role above all in destruction of soils.

Nivation as well as eolic processes show also high rates (especially as a retreat of the hollow borders by both the snow and wind action) but the area of their occurrence is rather small. The occurrence of those phenomena is conditioned by anemo-orographic systems of single mountains and therefore their importance is only local.

High mountain slopes in the West Carpathians are modelled markedly also by creeping. The rate of downslope creeping of mass soil with the alpine meadow cover is very slight (some millimetres to some centimetres per annum), though this process is very broaden. In return the rate of the creeping of loose debris on the slope surface is major (some centimetres per annum), but this form of creeping covers only small part of the total area. A local importance also debris avalanches along with other gravitation - fluvial processes mean (see M. Lukniš 1973, A. Nemčok 1972, P. Plesník 1971, T. Zięṭara 1974) but they are found only from time to time.

Among processes that are preparing a soil surface for destruction and for mass transportation, foremost the needle ice action can be consider in high-mountain areas of the West Carpathians. The frost heaving of soil is important, too. Finally the chemical denudation cannot be forgotten. Although a rate of the latter (some hundredth parts of millimetres per annum) cannot compete with the rate of rain wash, the chemical denudation is meaningful modelling factor of slopes (see A. Kotarba 1972b, E. Mazúr 1962) because carbonate bedrocks, namely limestones, are broadly occurrenced in Mesosoicum of the high mountains in the West Carpathians.

From among aggradation processes a rockfall is the most important factor of slope development. This morphogenetic process of rockwalls is typical one in the alpine and subnival belts. The rate of debris accumulation amounts to some tenths of millimetres up to some millimetres per annum but with regard to small area of occurrence this phenomenon does not counterbalance (perhaps with exception of the High Tatra Mts.) annual losses of both soils and debris caused by various erosive - transport agents (by water, wind, snow).

A nature of majority of destructed surfaces in soil and/or debris cover above the timberline is polygenetic. Therefore it is difficult to differ a part of single processes in modelling of the destructed surfaces. For this reason data that were obtained by means of direct semi-stationary micronivellation measurements (by the erosion gauge) on the bare destructed surfaces seem to be relatively the most objective ones. These data mean a resulting value of integrated intensity of all morphogenetic processes, that are contributing to modelling of bare part of slope in a certain place in relevant time.

From those data (R. Midriak 1979) is evident fact that on this same place of the slope once an accumulation during some years can be observed temporarily, afterwards again a denudation. Both these forms, however, can be found at once, too.

After a total evaluation of both the degradation and aggradation morphogenetic processes in high mountains we can claim that the transportation of mass (i.e. soil, debris, weathering products) prevails over the accumulation. The lowering of the bare surface of slopes (without rockwalls) is some millimetres per annum (on the average 7 to 8 mm). An absolute magnitude of the transportation or the accumulation of respective place is affected by various geographical influences, however, therefore a simplified universalization of the rate of degradation processes cannot be conclusive.

2.3. Potential and actual lowering of slope surfaces above the timberline

Before a conclusion of the evaluation of the morphogenetic processes rate in the high mountains the Table 2 is given in addition. In this table data on a mean potential annual washing of

Table 2

Comparison of potential lowering of slope surface and actual one in area above the timberline in high mountains of both the Czechoslovak and Polish part of the West Carpathians

Mountains - part	Area above the timberline (ha)	Rates of the mean retreat of slope surface ($mm.year^{-1}$)	
		potential	actual
Tatra Mts.	37 595	9.26	0.47
- High Tatra Mts.	- 19 100	9.10	0.25
- Belianske Tatra Mts.	- 1 657	9.52	0.86
- West Tatra Mts.	- 16 838	9.42	0.68
Low Tatra Mts.	14 410	7.71	0.20
Malá Fatra Mts.	3 349	7.33	0.60
- Krivánska Fatra Mts.	- 2 749	7.87	0.70
- Lúčanská Fatra Mts.	- 600	4.87	0.15
Veľká Fatra Mts.	3 080	7.98	0.43
Chočské vrchy Mts.	220	8.80	0.70
Oravské Beskydy Mts. (Beskid Żywiecki)	934	4.75	0.40
Total / Average	59 588	8.64	0.41

soil are arranged for comparison with those on actual lowering of slopes in the same high mountains of the West Carpathians. The latter are weighted mean of the rate all of morphogenetic processes from whole area above the contemporaneous timberline (i.e. for destructed surface, area of dwarf pine stands as well as area of alpine meadows). This data is necessary to consider as a final rate that should not be exceeded in all probability. It is concerned an expression of synthesis of the operation of destructive morphogenetic processes in area above the timberline.

Actual lowering of slope surface (i.e. soil loss or loss of weathering products) amounts to 0.15 to 0.86 mm per annum (on the average 0.41 mm per annum) in particular high mountains. It is 2.6 to 9.0 % (on the average 4.7 %) of the mean potential washing.

3. C O N C L U S I O N

In the end it is necessary to emphasize that an attention in a study of high mountains should be paid not only to the further giving precision to the rate data on morphogenetic processes, but also to investigation of the rate concerning weathering, soil - formation processes as well as an endogenic energy what is operated on contemporaneous crustal movements. Only in this way it will be possible to get, in confrontation with our data on the rate of retreat and/or lowering of slope surfaces owing to morphogenetic processes, an exact model of the contemporaneous development of relief in natural - economic conditions of high mountains in the West Carpathians.

S U M M A R Y

The rate of the mean retreat and/or the lowering of slope surfaces is 0.41 mm per annum in area above the timberline in high mountains of the West Carpathians. In the present the most

portion of slope modelling share erosion phenomena (especially rainfall erosion processes) but also nivation, eolian processes, mass creeping, needle ice and chemical denudation are important factors. Processes of degradation predominate over aggradation. The lowering of bare surface without a vegetation cover amounts to 7 - 8 mm per annum on the average. The actual rate of the slope retreat amounts to about 4.7 % of the mean potential intensity of the surface lowering in both the subalpine and the alpine belts in the West Carpathians.

Keywords: erosion, mass movements, cryogenic processes, chemical denudation, timberline

Zusammenfassung

Der Wert des mittleren Rückganges und/oder der Erniedrigung der Hangfläche ober der Waldgrenze im Hochgebirge der West-Karpaten beträgt 0,41 mm pro Jahr. Gegenwärtig sind an der Hangbildung meistenteils Erosionserscheinungen (vor allem Regen-Erosionsprozesse) beteiligt, aber auch Schneebedeckung, Windwirkung, Kriechen, Eisnadeln und chemischer Abtrag sind wichtige Faktoren. Degradationsvorgänge überwiegen die Anschüttung. Der Abtrag vegetationsloser Flächen erreicht Durchschnittswerte von 7 - 8 mm pro Jahr. Der gegenwärtige Hangabtrag beträgt daher 4,7 % der mittleren potentiellen Hangerniedrigung im subalpinen und alpinen Bereich der West-Karpaten.

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February 18, 1980.