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THE ROLE OF MUD AND DEBRIS FLOWS MODELLING OF THE FLYSCH CARPATHIANS RELIEF, POLAND

INTRODUCTION

There have been six disastrous floods (Cebulak 1998; Niedbała, 1997, 1998) in the Polish Carpathians during the last fifty years (1958, 1960, 1970, 1980, 1996, 1997) which have caused great changes in relief and have destroyed economic infrastructure within the reach of high water. The analysis of high water across an extended period of time indicates that torrential rains and floods never affect the entire Carpathian catchment area of the Vistula, but only particular groups of rivers; e.g. the western (Mała Wisła, Soła, Skawa and Raba), the middle (Raba, Dunajec, Wisłoka) and the eastern (Wisłoka, Wisłok, San) (Fig. 1). Rapid, heavy rainfalls and a high water level greatly increase the erosion and denudation of valley bottoms. This occurs when the water threshold level on the slopes is exceeded (Dauksza and Kotarba 1973; Gil and Starkel 1979; Gil 1979; Starkel 1996, 1998; Kotarba 1994; Bajgier-Kowalska 1996; Ziętara 1968, 1996, 1998 and others). Gradually increasing precipitation does not initially affect the balance on the slopes because weathered covers and rocks are able to contain a certain amount of water. In times of more intensive precipitation erosional and denudative processes become more active, but changes on the slopes remain very small (floods in the Beskidy in 1959 and 1972) until the slope stability threshold is exceeded. When this happens, even the smallest increase of precipitation causes very intensive slope processes (floods in 1958, 1960, 1970, 1996, 1997). Slope stability threshold depends not only on the amount of rainfall, but more importantly on the rhythm of precipitation proceeding heavy rainfall, which in turn influences the height and run of the high water level in valley bottoms. The same amount of disastrous precipitation (28–30% of annual average) with a different rhythm of proceeding precipitation causes different way of slope modelling (Kotarba 1986, 1994; Ziętara 1972, 1997, 1998).

In the high mountains (e.g. Alps, Caucasus, Tien-Szan, Himalayas and others) debris flows are frequent and cause great damages in the relief (Starkel 1972a; Froehlich and Starkel 1987; Ziętara 1976). They are episodic in

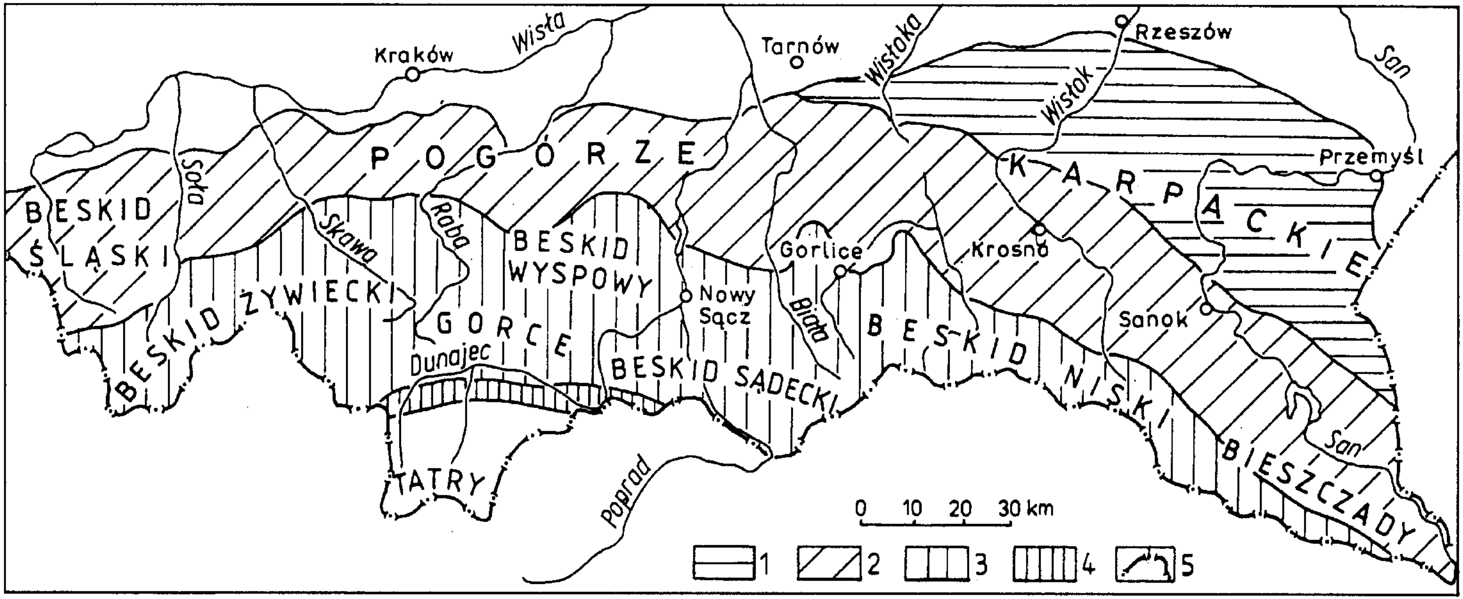

Fig. 1. Geomorphological units of the flysch Carpathians on the background of tectonics. 1 — skolska nappe, 2 — Śląska nappe, 3 — Magura nappe, 4 — the Pieniny, 5 — boundary of Poland

the Carpathians (Kotarba 1994; Ziętara 1997, 1998), but significantly influence relief modelling in the region.

MORPHODYNAMIC ZONES IN THE CARPATHIANS

Thick ground or weathered covers provide good conditions for the creation of debris-mud flow. The covers, by soaking in water, become plastic and flow with great speed down the slopes and into the valleys separating the Beskidy. The flows are formed when there is a high degree of slope incline and very intensive precipitation or snow melting fills slope deposits with water. According to the slope covers, mud, debris, or mixed (mud-debris) flows are created. The types and distribution of slope covers vary according to the morphodynamic zone in the flysch Carpathians (Starkel 1960, 1972b, 1972c; Kotarba 1976, 1986; Ziętara 1989 and others; Kotarba and Starkel 1972; Ziętara 1976; Starkel 1998) Four morphodynamic zones can be distinguished in the Carpathians: high montane, middle montane, foreland, and submontane zones.

The high montane zone (above 1,800 m a.s.l.) is more or less situated in the temperate cold and cold climatic belts (Hess 1965). Slope inclination is often higher than 80°, and the slopes are usually either free of any cover or are covered with a thin weathered mantle. Here, the slopes are cracked and mechanical weathering predominates (Kotarba 1976; Kotarba et al. 1983). Steep slopes are modelled by rockfall and are weathered and degradational. Gravitational movement causes fallen-out material to collect in gullies and at slope outlets, creating debris covers. During rapid heavy rainfalls, the collected material in gullies or debris slopes is quickly displaced in the form of debris flows. There are different heights in the zone within the north- and south-facing slopes (Hess 1965). The lower part of the zone is above the tree line and covers the belt of dwarf pine alternating with high montane pastures. Here slope inclination is usually 50–70°, and sometimes even greater. The most common slopes are weathering-gravitational (agradational) slopes and gravitational-talus slopes. There are also slopes built of solifluction covers. Huge landslides and widespread block fields resulting from deep-seated mass movements exist in such zones (Starkel 1960; Alexandrowicz 1978; Pękala 1969; Henkiel and Terpiłowski 1992 and others). One may say that the zones which are most susceptible to displacement from debris flows are those with the greatest amount of loose material (Fig. 2). A high degree of incline on slopes dissected by valleys with a high gradient also provides favourable conditions for the creation of debris flows in that zone.

The middle montane zone (from 800 to 1,800 m) is overgrown with coniferous and mixed forests and has a degree of slope incline of 40 to

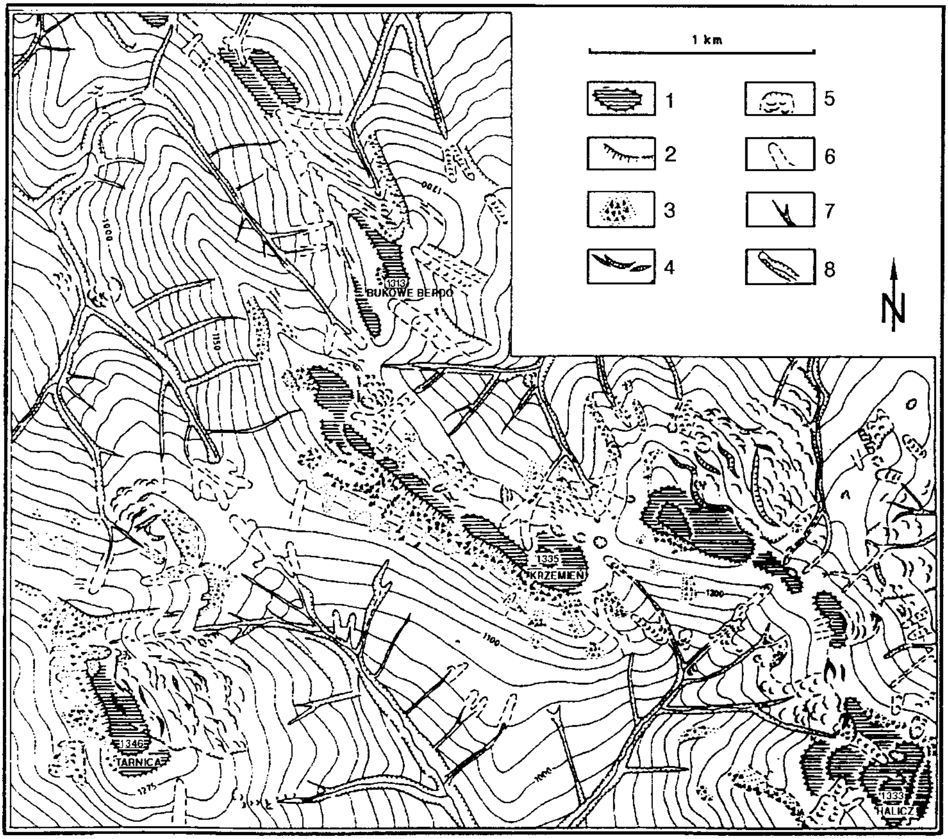

Fig. 2. Structural debris flows on slopes of Bukowe Berdo, Tarnica and Halicz in the Bieszczady. 1 — cryoplanational terraces, 2 — rocky ramparts, 3 — debris flows, 4 — cracks, 5 — landslide, 6 — plate-like valleys, 7 — V-shaped valleys, 8 — turbulent debris-mud flows

60°. In the Polish part of the Carpathians this zone contains the Beskidian slopes. In the Beskidian zone, debris-mud flows are created where steep outlets of valleys intersect with V-shaped valleys. The valleys are covered with colluvial deposits (colluvial-agradational slopes), debris material resulting from mechanical weathering (weathering slopes), or landslide material (colluvial slopes on Babia Góra, Pilsko, the Beskid Wyspowy, Beskid Śląski or Beskid Mały). Partially preserved landslide niches indicate that colluvial material collects in a thick layer (some 10 m thick) (Starkel 1960; Alexandrowicz 1978; Kotarba 1986; Ziętara 1989; Łajczak 1992). The surface consist of sharp-edged debris of various size, including larger, rocky blocks. Surfaces of colluvial slopes consist of many transversal ramparts. These are step-like and full of depressions without outlets and shallow basins. These basins are often dissected by V-shaped valleys which cut into landslide slopes. In some places, such as valley bottoms, there are great collections of debris and poorly pebbled blocks which are also displaced by debris flows.

The low montane zone (400–800 m) is characterised by a slope inclination of 20–45°. The slopes are covered with weathered, solifluction, colluvial/proluvial covers. In the flysch Carpathians large areas are occupied by colluvial and proluvial covers. The covers contain more clay than debris material, as chemical weathering predominates (Starkel 1960). In this zone flows occur occasionally, mainly in the form of mud flows. Currently slopes are modelled by creeping and sliding (Kotarba 1986; Starkel 1960; Ziętara 1968; Bajgier-Kowalska 1996).

The slopes in the foreland and submontane zone (to 500 m) have an incline of 5 to 35° and are covered with thick, clay-dusty covers. Almost the entire soaked zone is used for agricultural purposes. When clay, dusty, or sandy deposits are soaked with water, they provide good conditions for the creation of mud flows.They arise even on slopes with smaller inclinations, when the thickness of the deposits is large, there is strong saturation, and plant cover is poor or destroyed. These forms are very small.

TYPOLOGY OF DEBRIS-MUD FLOWS

There are two types of debris-mud flows in the Carpathians: turbulent and structural. Turbulent flows are more frequent, especially in the Polish part of the Carpathians (Ziętara 1976, 1998). In valley bottoms moving mass has liquid properties. Water-mud-debris mass in the valley bottoms or channels are 50–60% water and 40–50% clay or stony material. In turbulent flows one may notice material segregation and a poor sorting of single blocks. On the surface there are 0.9 × 0.5 × 0.3 m blocks or 0.6 × 0.3 × 0.2 m blocks. In the bottom part of stony-mud flows blocks are smaller and better sorted e.g. 0.2 × 0.1 × 0.05 m or 0.1 × 0.5 × 0.03 m (the valley of Zlatna in the Beskid Żywiecki in 1996 and 1997). The size of these blocks in specific montane groups in the Carpathians varies and depends on the structure of the deposits which supply material for debris-mud-flows. In their lower parts, however, greater blocks are rarely noticed (Kotarba 1998). In the lowest part of the debris-mud flow there is often a fine, clay-like material. This block segregation is caused by the fact that in the final phase of the movement of debris-mud flow, small-size blocks fill the empty spaces among the bigger blocks and gradually sink to the bottom of the flowing mass. The bottom part — which remains wet for the longest amount of time — possesses movements, which provide good conditions for the segregation and deposition of small-size material at the bottom. This part is also washed out during periods of higher water level (Fig. 3).

The segregation of material can also be observed in the transversal profile of turbulent flows. On both sides of debris-mud flows there is smaller material;

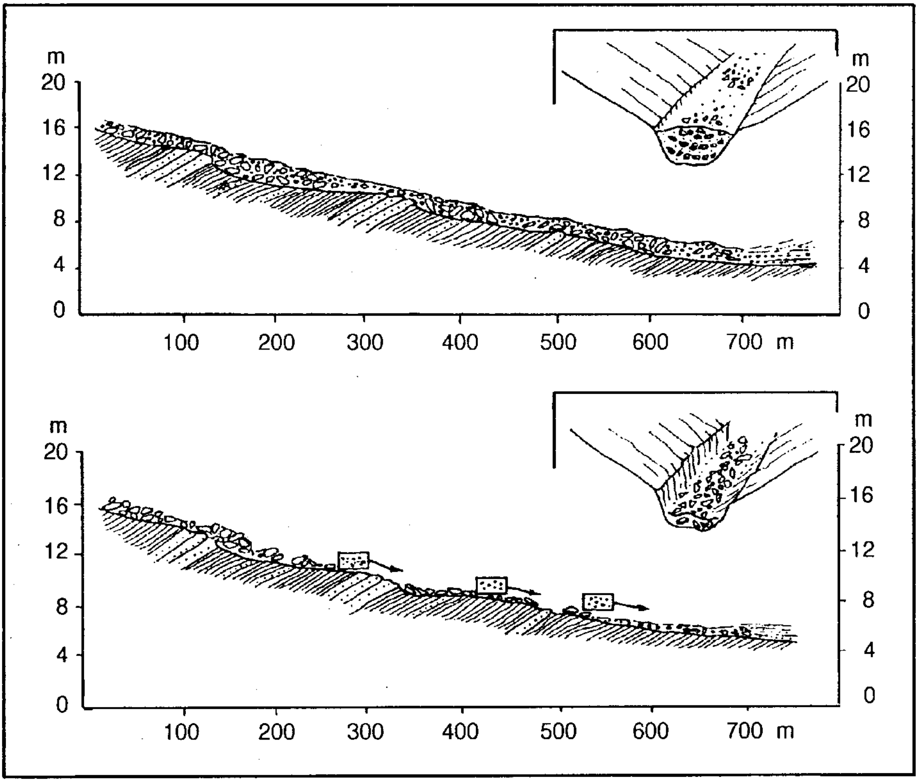

Fig. 3. Washed out material from debris-mud flow is transported during high water levels in multi-phase flood in the Beskid Śląski

the larger blocks are in the middle parts. The width of turbulent flows varies and generally depends on the width of the river-channel or river-bed. As they occur only in the upper parts of the Carpathian valleys, their width varies from 12 to 30 m. Their thickness does not exceed 3 m and their length differs according to not only on the slope inclination on which debris-mud flows begin, but also on the gradient of the valley or tributary valley. The rhythm and size of rapid rainfalls are also important factors. Turbulent flows occur mainly in the lower part of the middle montane morphodynamic zone and torrential cones are formed at valley outlets. Within turbulent flows the following can be distinguished (Ziętara 1976): 1 — water-debris flows with a predominance of thick material, 2 — water-sandy flows in which the sandy element is predominant, 3 — water-dusty flows in which clay-dusty material is predominant. In the middle montane zone of the Carpathians, mixed types (e.g. water-debris-clay or water-clay-debris flows) are more frequent; in the high-middle montane zone, water-debris flows predominate (Fig. 4).

Debris flows occur mainly in the high montane zone, and sometimes also in the middle montane zone. They are formed on debris-mantled slopes and

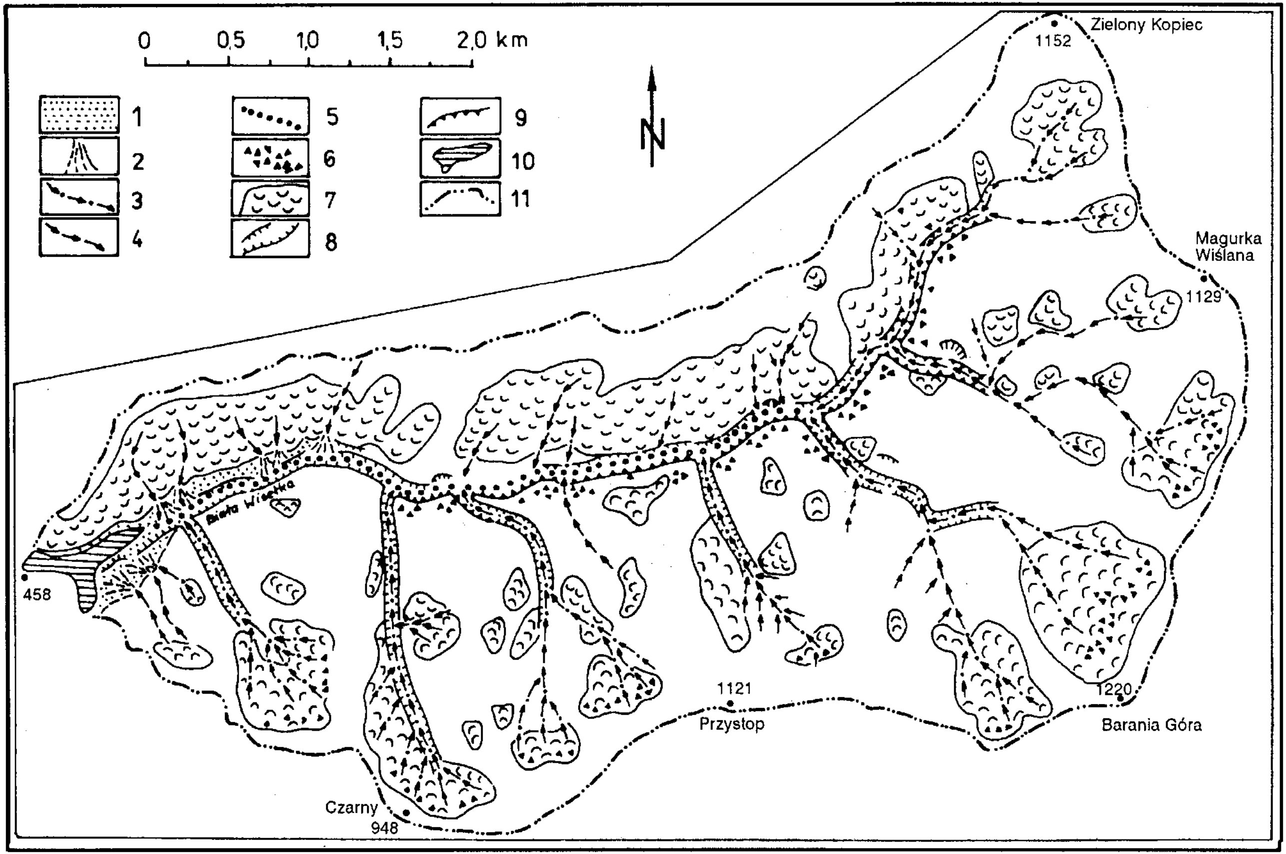

Fig. 4. Debris-mud flows in the Biała Wisełka catchment basin in the Beskid Śląski in 1996 and 1997. 1 — accumulation terrace plains, 2 — torrential cones, 3 — debris flows, 4 — mud flows, 5 — turbulent debris-mud flows, 6 — debris covers, 7 — landslide, 8 — river undercutting, 9 — rocky undercutting, 10 — water reservoir, 11 — watershed

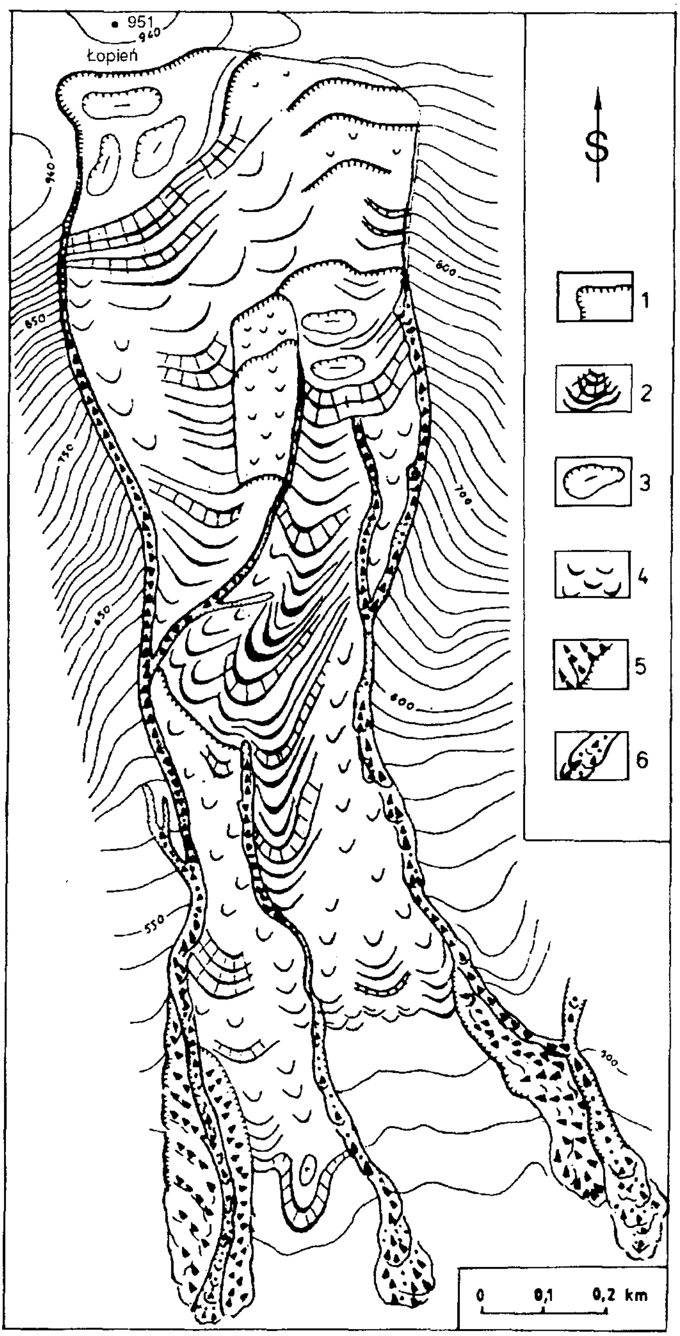

Fig. 5. Landslide on the northern slopes of Łopień in the Beskid Wyspowy, many times modelled by debris-mud flows. 1 — edges of the landslide niche, 2 — landslide ramparts, 3 — depressions within the landslide, 4 — landslide surfaces, 5 — older deposits from debris flows, 6 — younger deposits from debris-mud flows

create long and deep channels. Sometimes they are accompanied by longitudinal levees (Kotarba 1994). Displaced material is sharp-edged and the width of debris flows is varied, with the widest reaching 35 m (the Tatra Mts). The front of the debris flow track is convex and, when consisting of big blocks of materials its inclination varies from 35–42° (Kotarba 1994, 1998).

Debris-mud and mud-debris flows differ in the amount of displaced debris or mud material. They occur mainly in the high and middle montane zones. Debris-mud flows fill V-shaped valleys. This happens in the final phase of a torrential rain or flood. Debris material in the flow mass is sharp-edged (Ziętara 1968) and the size of the rocks often exceeds 1 m in diameter, sometimes reaching 1.5 m. The material is neither bedded nor segregated and its thickness can reach 6 m and its width up to, but not over 40 m. In the longitudinal profile, the surface of the flows creates numerous levees and windings. In the accumulation zone there is a phenomena of overlapping of debris-mud flows tongues. Mud flows occur on areas covered with thick clay-loess covers. In the Carpathians they are very rare. Using the role of water within structural flows as a criterion, one may distinguish (Ziętara 1976, 1998) three phases of displacement: 1 — the introductory phase, in which water reanimates the movement of the plastic liquid mass on the inclined plane, 2 — the main phase, in which water takes part in the movement of solid mass by providing it with some plastic properties which not only enable the solid mass to overcome friction, but also give it enormous destructive potential, 3 — the final phase, in which accumulation is caused by a decrease of gradient, but not by a lack of a suitable amount of water.

The speed of structural flow movement is different and varies from 10–20 km per hour. It depends on not only the incline of the base, but also on the structure and texture of the displaced mass and on the rhythm of the heavy rainfall which gives the mass its plastic-liquid movement. The speed of mass displacement in the transversal profile of the flow is also different; it is greater in the middle part than on periphery (Kotarba 1994; Ziętara 1998), and displaced material intensively erodes the bottom and valley slopes.

Debris-mud flows affect valley bottoms with a high degree of gradient. These bottoms are filled with material during disastrous heavy rainfalls and floods and are often dissected during the normal high water period that follows (Ziętara 1968, 1997). During a single heavy rainfall the material can be set in motion twice by debris-mud flows (Fig. 5).

DEBRIS-MUD FLOWS IN THE BESKID WYSPOWY AND ŻYWIECKI

Debris-mud flows in Beskid Wyspowy and Żywiecki occurred on an unparalleled scale in 1997. They were caused by very intensive precipitation between July 4 and 9, 1997, and created disastrous floods on many rivers in the Western Carpathians. The precipitation resulted from stationary low pressure over a period of six days (Niedźwiedź and Czekierda 1998). On July 9, in the final phase of high water, there was rapid, extremely intensive, disastrous rainfall (150 mm during two hours) in the western part of the Beskid Wyspowy.

The Beskid Wyspowy is characterised by quite different relief than the other parts of the flysch Carpathians. The Beskid Wyspowy contains isolated hills which are 900–1,000 m high. The highest are Mogielica (1,171 m), Ćwilin (1,071 m), Jasień (1,062 m), Luboń Wielki (1,022 m), Sałasz-Jaworz (917 m).

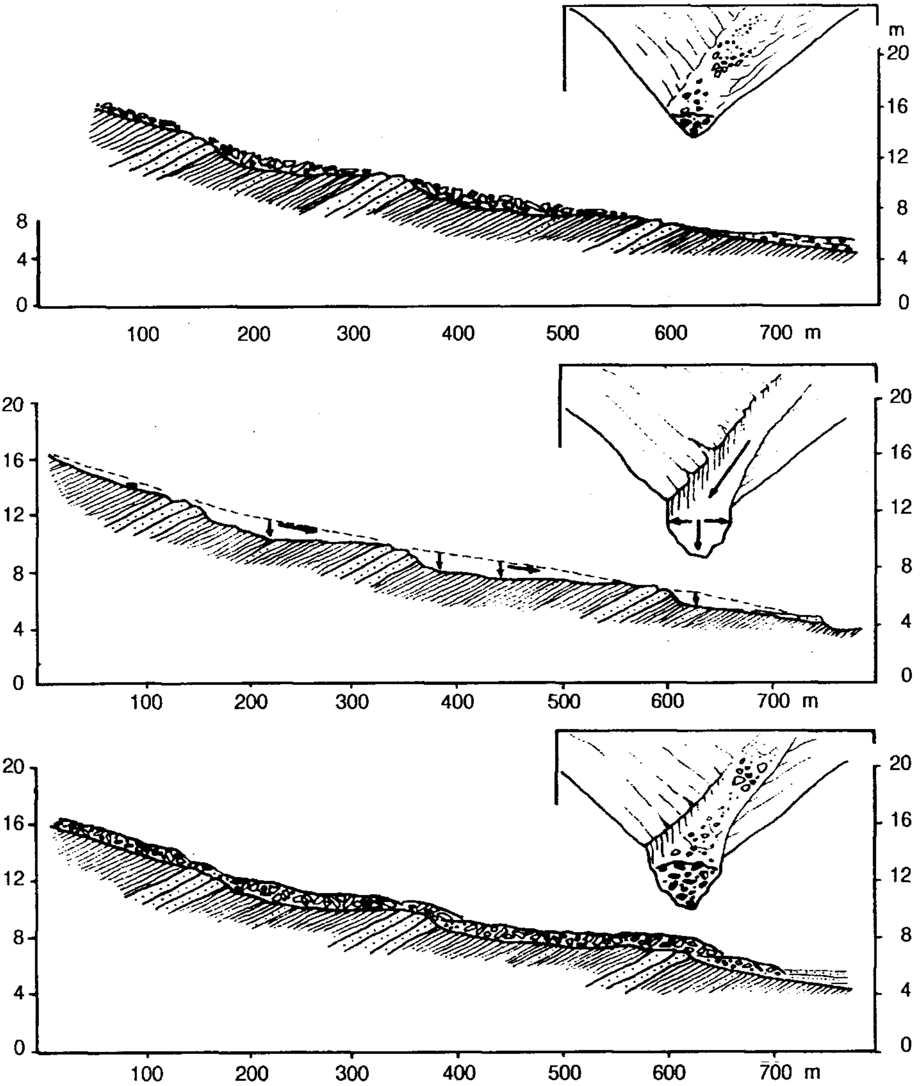

Fig. 6. Erosion and accumulation phases in V-shaped valleys deepened by debris-mud flows

The Beskid Wyspowy is built of Magura overthrust, the upper part of which is longitudinally and transversally folded and flattened by the Beskidian planation level. There is an inversion of relief and the slopes of the isolated hills in their upper parts are made of hard, Magura sandstones. There are inverted valleys and dales among the isolated hills and the pattern of valleys is rectilinear. The slopes are shaped by deep, rocky landslide niches, within which are Magura sandstones; debris-clay tongues are in the submagura deposits (Bajgier-Kowalska 1998).

On July 9th, 1997, there was a strong storm and within two hours there was more than 100 mm of precipitation, reaching 135 mm at Rozdziele station. The storm caused a rapid flow of water, which flowed not only linearly (in valleys, depressions, roads) but also laminarly — totally covering the slope surface. In a short time narrow streams turned into huge rivers flooding not only valley bottoms but also higher terraces. The maximum precipitation and flood wave occurred nearly at the same time.

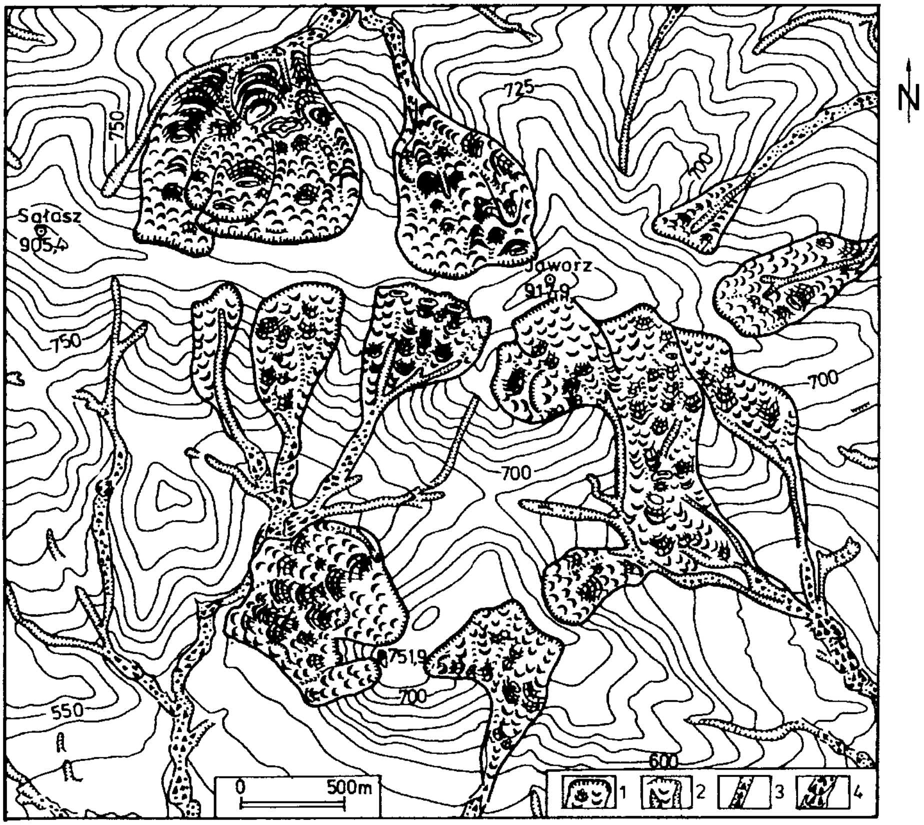

Fig. 7. Debris-mud flows within landslides on the Sałasz-Jaworze slopes in the Beskid Wyspowy in 1997. 1 — landslide, 2 — landslide dissected by debris flows, 3 — material from debris flows in V-shaped valleys, 4 — overlapping debris tongues

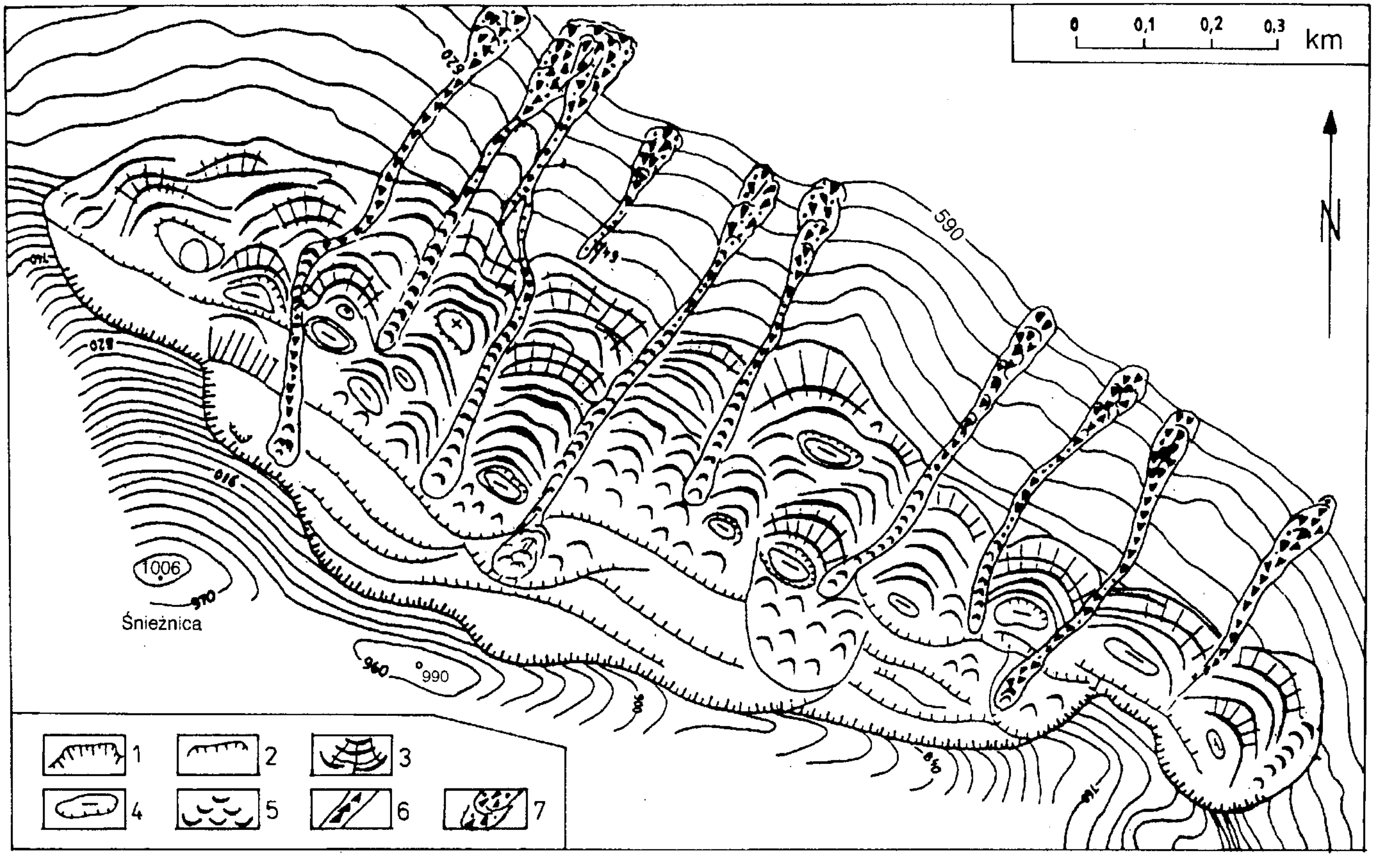

Fig. 8. Frontal landslide on the northern slopes of Śnieżnica in the Beskid Wyspowy dissected and modelled by debris flows.
1 — edges of landslide niche, 2 — edges within the landslide, 3 — landslide ramparts, 4 — depressions within the landslide, 5 — corrasional channels, 6 — debris-mud tongues, 7 — overlapping debris tongues

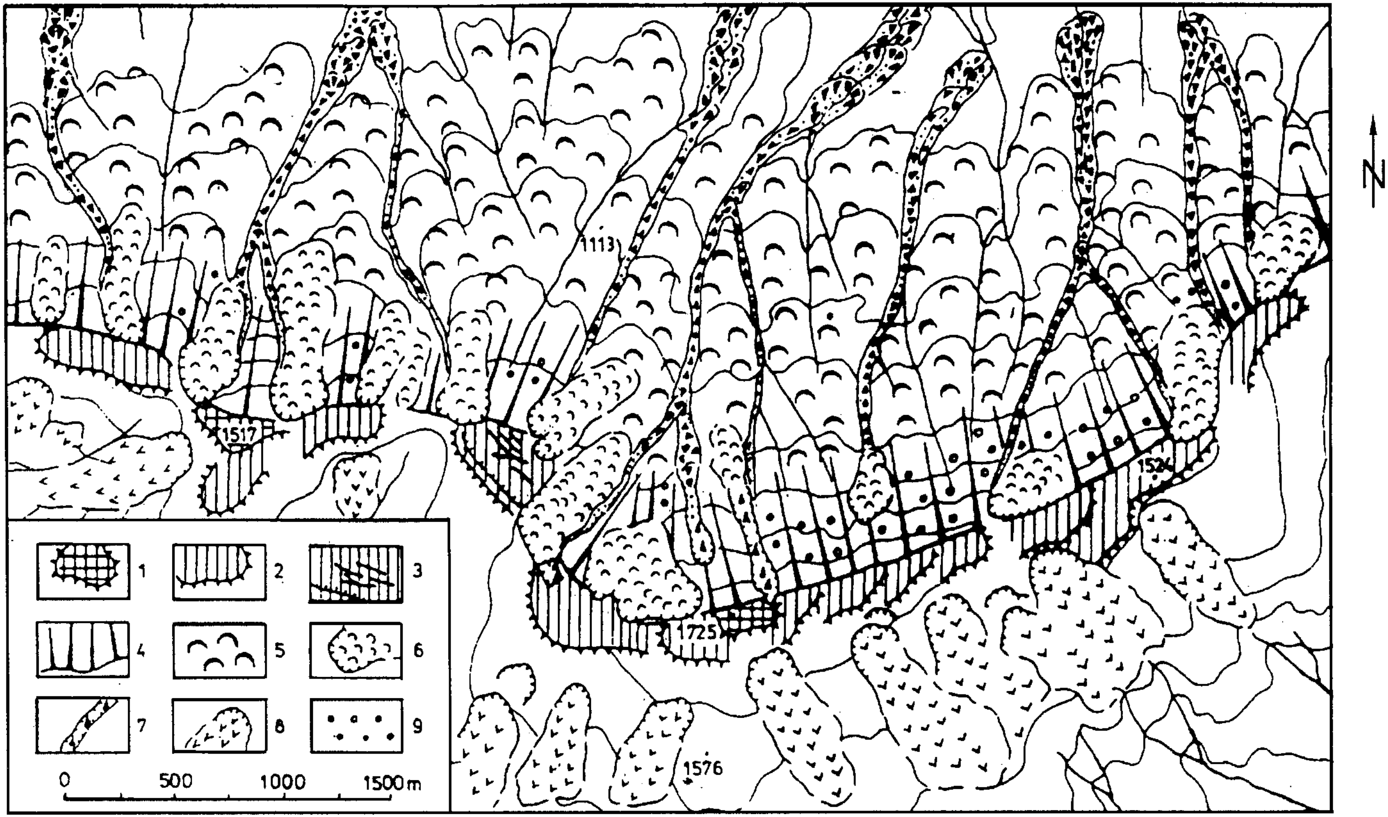

Fig. 9. Structural debris-mud flows formed in 1996 and 1997 on the northern slopes of Babia Góra. 1 — frost tors, 2 — cryoplanation terraces, 3 — cryoplanation terraces with contemporary slump fissures, 4 — niche wall of great slump by S. Alexandrowicz (1978), 5 — huge slump and landslide tongues, 6 — niches and colluvial belts of posthumous consequent-fissure landslides modelling walls of huge rock slump niche, 7 — corrasional 9 — debris and rocky material

Very quick linear flow deepened the field paths from 0.5 to 1.5 m and rolled roads with an incline of over 5°. Generally, the slopes were intensively dissected by erosion. The V-shaped valleys were deepened and debris-landslide material which had been collected during the previous high water was totally removed (Fig. 6). Normal V-shaped valleys were deepened and changed into chest-like valleys. Those valleys were modelled by turbulent debris-mud flows in which the liquid phase predominated. In the bottom part there was smaller debris material in clay mass form. At the valley outlets large debris (torrential) cones formed. On slopes covered with thick clay-dusty covers there were formed wide mud flows which disastrously changed slopes of Laskowa, Młynna, Kamionka Mała, Ostra Góra, Modynia and others.

The majority of deep, rocky landslides modelling the slopes of Łopień, Śnieżnica, Ćwilin, Paproć, Jaworz-Sałasz, Miejska and Łysa Góra were dissected and debris flows were formed, which moved quickly to create corrasional channels (Fig. 7). Trees growing on landslides were uprooted and broken like matches. The flows were followed by loud noises caused by the internal friction of the blocks and the breaking trees. In the final, accumulation phase these flows made a convex debris tongue consisting of big blocks. Accumulation was caused by the decrease in incline, not by the lack of a sufficient amount of water (Fig. 8).

The Beskid Żywiecki does not consist of one range but rather of many ranges differently dissected. The relief is of inversional character and slope inclinations are varied (Ziętara 1968). The upper parts of slopes are steep (40–80°), and made of Magura sandstone, a range-making material. The biggest range is the Babia Góra (1,725 m), with edged slopes modelled by huge rocky landslides (Fig. 9). The Pilsko range (1,557 m) is radially dissected by a deep valley and, in the spring parts, of those valleys are subject to big landslides. The southermost is the Wielka Racza range (1,236 m), with a concentric pattern of valleys.

As a result of small displacements of low pressure (from July 4–9), rainfall during those four days reached 602 mm (Niedźwiedź and Czekierda 1998). On July 8, it reached 200 mm in the Beskid Żywiecki. This created a high, disastrous water level which continued for a longer time (Niedbała 1998).

Large areas of old, deep-seated landslides remain on the slopes of Babia Góra, Pilsko, Romanka, Lipowska and others (Ziętara 1968, 1988; Łajczak 1992; Bajgier-Kowalska 1994). They were formed during the contact of Magura sandstones and deposits with slate predominance (submagura, hieroglyphic, spotted slates and others). In the upper part they are rocky-pack landslides within clearly preserved niches. In their lower parts they are plastic-debris (Fig. 10A). This is the reason why debris-mud flows form in such areas. The upper parts of these landslides were dissected during heavy rainfall and formed debris-mud flows (on slopes of Babia Góra, Pilsko, Romanka). In their lower parts they were rejuvenated (on the slopes of Romanka, Lipowska, Wielka Racza and others). Water rapidly flowing down the slopes disappeared into landslide cracks like through a sieve. In the lower parts of the landslides

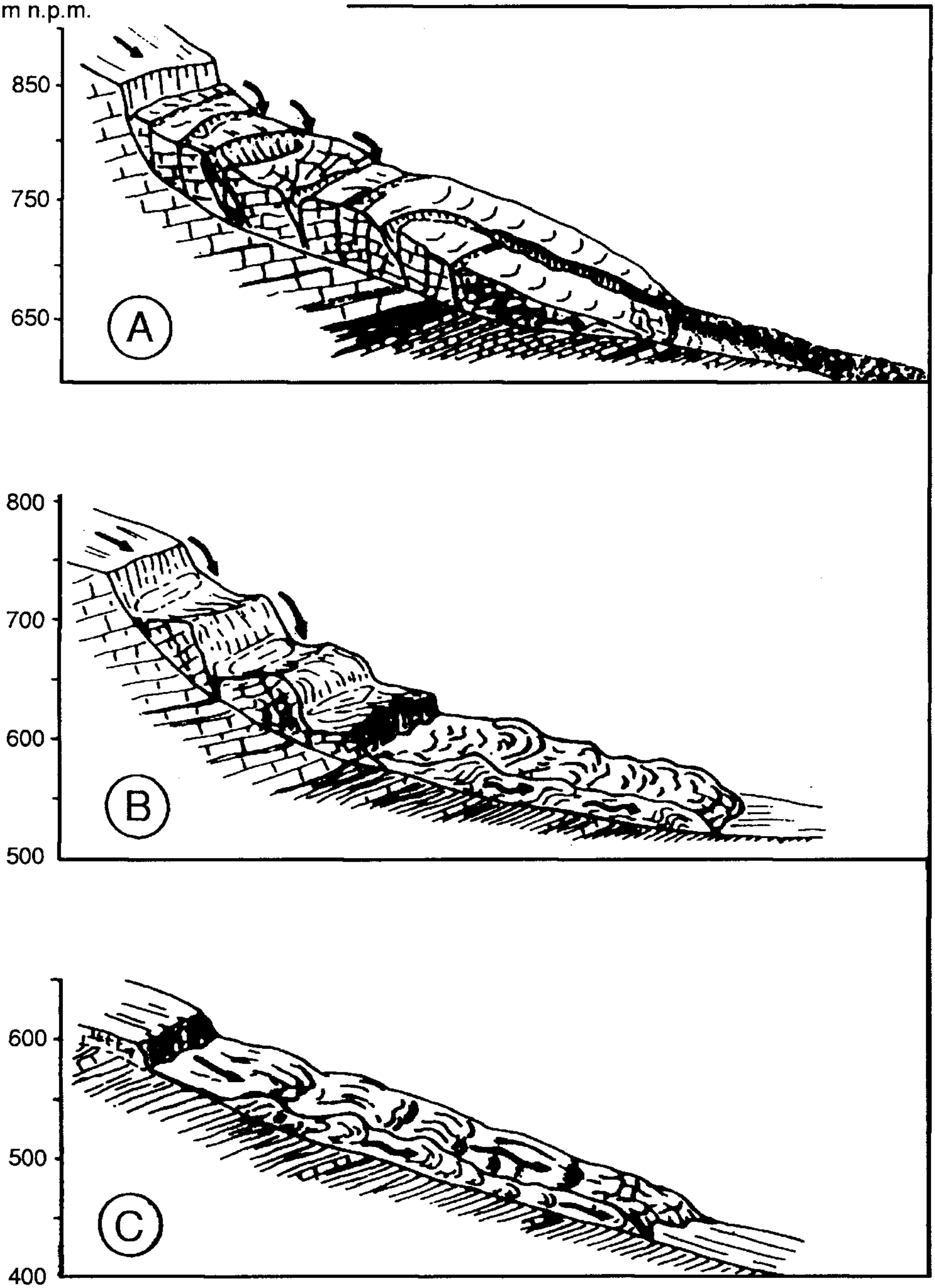

Fig. 10. Different types of landslides modelled by debris-mud flows in the Beskid Żywiecki and Wyspowy. A — deep rocky landslides dissected by debris flows, B — rocky-plastic landslides supplied material to debris-mud flows, C — plastic landslides supplied material to mud flows

the water pressure caused the displacement of the unpermeable, saturated plastic-debris tongues (Fig. 10B). The material initiated the mud-debris flows. New slidings which enlarged landslide surfaces also formed. These slidings were shallow and their thickness did not exceed 3 m.

Within the thick weathering, solifluction or colluvial covers on steep slopes (over 40° of inclination) of the Beskid Żywiecki and Wyspowy, numerous shallow landslides and mud-flows formed (German 1998; Poprawa and Rączkowski 1998; Ziętara 1997, 1998). Within the Beskid Wyspowy approximately 130 new landslides occurred in 1997 (Poprawa and Rączkowski 1998). This often supplied turbulent mud flows with material (Fig. 10C).

In valleys with an even gradient (below 10‰) and flat, terraced bottoms, concrete bands, artificial dams, and rapids were destroyed. The valley bottoms were also widened, while the slopes and edges of higher terraces were undercut. During the flood, stones were displaced down the valleys and new point bars were formed (Froehlich 1998; Malarz 1997). Flood terraces were also affected by the sedimentation of gravel material. On the middle terraces fine clay material was deposited, and at the valley outlets which dissect the Beskidian slopes huge debris-mud cones were formed.

FINAL REMARKS

In the flysch Carpathians mud-debris flows vary according to morphodynamic zones. Their frequency is the greatest at the Beskidian level, where slopes and spring areas contain a great amount of weathering-debris, colluvia (debris-pack or debris-clay), and other covers.

Three types of valleys modelled by debris-mud flows were distinguished: 1 — V-shaped valleys or gullies with a high degree of incline (often more than 100%), which dissect the Beskidian slopes, 2 — flat-bottomed valleys which dissect the slopes ranges (e.g. Rycerka, Zlatna, Żabnica, Sopotnia Wielka, Jaworzyna Babiogórska, Rybne, Jałowieckie, Góra Mszanka, Poręba, Starowiejski Potok, Mordarka, Kamienica Górna and others), 3 — main valleys which dissect different tectonical and morphological units such as the Soła, Koszarawa, Skawa, Dunajec and others and dales with wide, terraced bottom and small slope inclination (not exceeding 10‰).

Structural debris-mud flows occur mainly in V-shaped valleys. The Beskidian valleys which gather waters from peripheral V-shaped valleys, are modelled by turbulent debris-mud flows. They decide on flooding in bottoms of bigger valleys. Accumulative material is sporadically transported, leading to the gradual deepening of valleys, the dissecting of the Beskidian slopes, and the filling of the foreland and intermontane basins.

Long term or heavy, disastrous rainfall causes debris-mud flows. These are formed during periods of long term precipitation (supplies from 200–300 mm, 2–3 hours lasting rainfall supplies from 100–150 mm of water). They also depend on the rhythm of precipitation that precedes heavy rainfall.

In the Western Beskidy debris-mud flows occurred during long periods of precipitation in 1958, 1970 and 1997; mud flows occurred in 1960 after a month-long period of precipitation with heavy rainfall at the end. Under such condition slope modelling by landslide processes took place, which supplied material to mud or debris-mud flows. The greatest structural debris-mud flows were registered in the Beskid Wyspowy and Żywiecki in 1997 after heavy precipitation.

During long term and heavy rainfall, debris-mud flows serve as indirect phases between gravitational movements of rocky masses and fluvial processes. The debris-mud flows also significantly influence erosion, transportation and accumulation in large valleys supplied with great amount of material from structural and turbulent debris-mud flows.

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STRESZCZENIE

T. Ziętara

ROLA SPŁYWÓW GRUZOWO-BŁOTNYCH W MODELOWANIU RZEŹBY POLSKICH KARPAT FLISZOWYCH

W pracy przedstawiono rolę spływów gruzowo-błotnych na tle pięter morfodynamicznych w Karpatach. Wyróżniono cztery piętra: wysokogórskie piętro (powyżej 1800 m), średniogórskie piętro (od 800–1800 m), niskogórskie piętro (od 400–800 m) i piętro pogórzy oraz przedgórzy (do 500 m). Przedstawiono także typologię gruzowo-błotnych potoków oraz ich wpływ na rzeźbę terenu.

W Karpatach fliszowych spływy gruzowo-błotne nawiązują do pięter morfodynamicznych. Częstotliwość ich jest największa w piętrze beskidzkim, w którym na stokach oraz w lejach źródłowych znajduje się bardzo duże nagromadzenie pokryw wietrzeniowo-gruzowych, koluwialnych (gruzowo-pakietowych lub gruzowo-gliniastych) i innych.

Wyróżniono trzy typy dolin modelowanych przez spływy gruzowo-błotne: 1 — wciosowe doliny lub żleby rozcinające stoki beskidzkie o bardzo dużym spadku, często powyżej 100‰, 2 — płaskodenne doliny beskidzkie rozcinające pasma górskie np. Rycerki, Złatnej, Żabnicy, Sopotni Wielkiej, Jaworzyny Babiogórskiej, Rybnego, Jałowieckiego, Górnej Mszanki, Poręby, Starowiejskiego Potoku, Mordarki, Kamienicy Górnej i innych, 3 — doliny walne rozcinające różne jednostki tektoniczno-morfologiczne (Soła, Koszarawa, Skawa, Dunajec i inne) oraz kotliny o szerokim sterasowanym dnie i małym spadku nie przekraczającym 10‰.

W dolinach wciosowych najczęściej występują strukturalne gruzowo-błotne spływy. Doliny beskidzkie zbierające wody z bocznych wciosów są modelowane przez turbulencyjne spływy gruzowo-błotne. Spływy te decydują o procesach powodziowych w dnach większych dolin. Materiał akumulacyjny przenoszony jest skokowo, a w efekcie prowadzi to do stopniowego pogłębiania dolin rozcinających stoki beskidzkie i zasypywania kotlin śródgórskich i przedgórskich.

Na uruchomienie spływów gruzowo-błotnych w zasadniczy sposób wpływają rozlewne lub ulewne katastrofalne opady. Powstają one przy opadach rozlewnych zakończonych gwałtownymi ulewami; trzydniowy opad waha się od 200–250 mm lub po dwugodzinnej ulewie powyżej 100 lub 150 mm. Są one także uzależnione od rytmu opadów poprzedzających gwałtowną ulewę.

W Beskidach Zachodnich spływy gruzowo-blokowe wystąpiły w czasie rozlewnych opadów w 1958, 1970 i 1997 roku, natomiast spływy błotne w 1960 roku po długotrwałych miesięcznych opadach zakończonych ulewą. W roku tym nastąpiło modelowanie powierzchniowe stoków przez

procesy osuwiskowe, które dostarczyły materiałów do spływów błotnych lub gruzowo-błotnych. Największe strukturalne gruzowo-błotne spływy miały miejsce w 1997 roku w czasie gwałtownych opadów w Beskidzie Wyspowym i w Beskidzie Żywieckim.

W czasie rozlewnych i ulewnych opadów spływy gruzowo-błotne są ogniwem pośrednim pomiędzy grawitacyjnymi ruchami mas skalnych a procesami fluwialnymi i w zasadniczy sposób wpływają na przebieg procesów erozji, transportu i akumulacji w dużych dolinach, do których dostarczane są olbrzymie ilości materiału przez strukturalne i turbulencyjne spływy gruzowo-błotne.