PRELIMINARY TWO - FOLD CLASSIFICATION OF TORRENTS

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SUMMARY

Based on recent theoretical and practical experiences in the field of torrents control now a two - fold classification of torrents is presented. The bipartition is a result of the requirements on the one hand it gives a total judgement about the behaviour of the torrent in the area of the torrent cone and on the other hand to explain the conditions which cause the development of this torrent in different parts of the basin and to determine the kinds of counter measures. In the first part of the total judgement of the behaviour of the torrent along the cone or lower course there are four types of torrents distinguished in view of variable danger to objects: Debris flow torrents, debris flood torrents, bedload transporting torrents, flood creeks. The second part of the classification distinguishes the torrents on form of action of surface discharge and discharge with embankment failures in the debris sources and the special and composite torrents too. The further differentiation is given between torrents with depth erosion and torrents with only lateral erosion and also between natural and human influences. In the lowest level of differentiation the natural scour torrents (colluvial scour torrents, volcanic scour torrents, bedrock scour torrents, partial scour torrents, torrents with strong infiltration, gullies, debris accumulating torrents) and induced scour torrents and further natural lateral erosion torrents (torrents with predetermined channel bends, torrents with free meanders, grass - scar torrents) and induced lateral erosion torrents are distinguished. The group of the special torrents is divided into ice - debris, snow - debris avalanches, Karst - torrents, glacial torrents, earthquake torrents. The type of the torrent in the lowest level of differentiation expresses type and cause of the erosion development in different torrents or parts of these. This type is linked with an index of possible maximum development which is divided into five steps. The classification permits correlations for hazard - zoning on the one hand (part 1) and to counter measures in different parts of the torrent on the other hand (part 2). The classification is not limited by the area of the Alps in its application.

ZUSAMMENFASSUNG

Auf Grund der neuen praktischen und theoretischen Erfahrungen und Erkenntnisse in der Wildbachkunde wird eine vorläufige, zweigeteilte Wildbachklassifikation vorgelegt und begründet. Die Zweiteilung ergab sich einerseits aus dem praktischen Erfordernis, am Schwemmkegel bzw. am Unterlauf das Gesamtverhalten des Wildbaches im Hinblick auf die Abgrenzung von Gefahrenzonen beurteilen zu müssen, anderseits aus der Tatsache, daß innerhalb des Wildbaches lokal verschiedene Ursachen für die Geschiebebildung vorhanden sein können und dementsprechend eine gesonderte Beurteilung im Hinblick auf die zu treffenden Verbauungsmaßnahmen verlangen. Im Rahmen der ganzheitlichen Beurteilung am Schwemmkegel werden im Hinblick auf ungleiche Gefährdung von Objekten vier Wildbachtypen unterschieden: Murstoßfähige Wildbäche, murfähige Wildbäche, geschiebeführende Wildbäche und lediglich hochwasserführende Wildbäche. Die im zweiten Teil vorgestellte Wildbachbeurteilung im Einzugsgebiet gliedert die Wildbäche zuerst nach Wirkungen der Obertag- und Untertagwässer in den Geschiebeherden, sowie nach besonderen und gemischten Wildbächen. Die weitere Untergliederung unterscheidet Wildbäche bzw. Wildbachabschnitte, verursacht durch Tiefenerosion und Wildbäche und durch Korrosion entstandene, wobei jedesmal natürliche oder anthropogene Ursachen zur Bildung der Geschiebeherde führen können (künstliche und natürliche Tiefenerosions- und Korrosionswildbäche). Diesen Erosionswildbächen, die selbst ihre Geschiebeherde dynamisieren, werden die Hanganbruchsbäche gegenübergestellt, die Geschiebe lediglich aus Hanganbrüchen empfangen und weitertransportieren. Die letzte Untergliederung drückt direkt Art und Ursache des Erosionsvorganges im Wildbach bzw. Wildbachabschnitt aus und ergibt die letztliche Typenbezeichnung, die mit einem Index der Entwicklungsfähigkeit verbunden wird (Stufen 1 - 5). Demnach sind zu unterscheiden: Lockergesteinsfeilen, Festgesteinsfeilen, Bäche mit nur örtlicher Tiefenerosion, Wasserverlustbäche, Gullies, Schuttstapelbäche, Aschenmuren, Zwangskrümmungs - Wildbäche, freie Mäander in Umlagerungsstrecken, Rasenschälbäche, Hanganbruchsbäche, (bedingt durch verschiedene Ursachen), Eismuren, Schnee - Erdlawinen, Karstbäche, Gletscherbäche und Erdbeben - Wildbäche. Die geschilderte Typisierung erlaubt ebenso Bezüge zur Zonenabgrenzung (Teil 1) wie zu den zu treffenden Verbauungsmaßnahmen (Teil 2). Ihre Anwendung ist nicht auf das Gebiet der Alpen beschränkt.

INTRODUCTION

The last Austrian classification of torrents by Stiny (1931) is now 50 years old. It is based on a geological approach. Since that time new parameters for the evaluation of torrents have become significant and thus have shifted the emphasis according to the new demands. Today a classification of torrents should fullfill three principal functions:

a) It should serve as a practical tool within the framework of the complex real world;

b) It should be accurate as to the effects and hazards to be expected on the debris cones;

c) It should express the genetic role of torrents in the dynamic evolution of valleys;

We still do not have the necessary scientific background information on mass flows and catastrophic events to lay the groundwork for an exact classification applicable in all practical situations and for a numerical analysis of future torrent activity. This is particularly true with regard to a scheme intended for world - wide use. This paper proposes therefore a preliminary classification which considers the present state of theoretical knowledge and takes a step forward in practical application. Inspite of most important geological parameters as emphasized by Stiny (1931), the present approach deviates from this point of view. The relationship between a certain type of torrent and an appropriate control system within the catchment basin or the application of active and passive measures on the debris cone can only be touched on a fundamental way. This relationship is greatly influenced by the variety of possible torrent - ecological parameters on the one hand and the variety of preventive measures on the other hand.

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The classification considers

a) the type of the extreme catastrophic events on the debris cone (or lower torrent course) supplemented with a torrent - index (Aulitzky 1973), (see Appendix) to use in torrent hazard zoning of natural debris cones and

b) the type and trend of the erosional processes in the catchment basin.

By definition, torrents flow from small basins (up to 100 km^2); wild rivers from larger basins. Both are perennial or intermittent water courses and by their transport of solid materials become the source of significant damage. For practical purposes it is therefore recommended to subdivide torrents as to their damaging behaviour along the lower course and according to the causal parameters contributing to this behaviour in the debris source area of the catchment basin. Appropriate temporary and permanent measures can then be taken if character and magnitude of the processes are understood. In all cases the extreme or potentially extreme behaviour are the basis for the characterization of a torrent. It is clearly understood that any torrent may, under favourable circumstances, remain far below its catastrophic level.

1 Classification as to the extreme Catastrophic Behaviour on the Debris Cone (Debris Fan, Lower Course, Redepositional Reach or on an other point of the Basin)

As long as the parameters along a torrent remain the same as the extreme event on the debris cone, debris fan, lower course and redepositional reach, these can be used for a general charcterization of a torrent. This concept is also used in the new bedload theory of Hampel (1969, 1970, 1980). In catchment basins, different torrent segments and debris sources along the embankment may become prominent. It is usually difficult to classify all of them under one "torrent - type". In such a case the characterization will have to be limited to homogeneous torrent segments, whose quantitative significance will vary as to whether they influence a redepositional torrent reach or the debris cone. Thus several types of debris sources contribute to the deposits of the cone. The catastrophic behaviour of the torrent as indicated by the deposits of the cone is particularly significant in overall evaluation of the torrent and in the hazard zoning. A distinct behaviour of torrent on the debris cone corresponds to a distinct set of preventive measures or afforestation techniques. Four torrent types (Tab. 1) have been differentiated, based on the formerly three types of Aulitzky (1973):

1.1 Debris flow torrents (Murstoßfähige Wildbäche).
1.2 Debris flood torrents (Murfähige Wildbäche).
1.3 Bedload torrents (Geschiebeführende Wildbäche).
1.4 Flood creeks (Nur Hochwasser führende Wildbäche, Gießbäche).

The torrent - index (see Appendix) has been developed for torrents in residual colluvium ("Altschuttbäche" by Stiny (1931), but it can be modified for other types of debris sources and assures a certain level of awareness of "silent witnesses" (hazard indicators) left behind by large flows in the past.

Table 1. Types of torrents with regard to resulting hazard along the cone, fan, lower course, redepositional reach, bottom of the valley or at any other point of the basin (completed after Aulitzky 1973)

1.1 Debris flow torrent	Non - Newtonian viscous, gravitational flows with pulsating and blocking debris *discharge reaching velocities of more* than 100 km/h; considerable impact forces; "box - shaped" cross sections of deposits by high - velocity flows with abrupt and steep margins; transport of large blocks along radial ridges towards the lower parts of the cone; common in torrents flanked by voluminous and slightly indurated residual colluvium ("Altschuttbäche" *of Stiny 1931); formation of steep* cones (Fig. 1, 2).	Very dangerous particularly if a potent debris source is close to the cone, separated from it only by a gorge; debris flows can jump the channel and spread over the whole fan without warning and with destructive impact; solidly built houses may be demolished; it is possible that stacked arrays of check dams along the torrent course are bypassed and that trapezoid discharge sections are breached; discharge sections should preferable imitate the flow profile of *debris flows* (i. e. the gently curved downward convex "Murprofil"); a series of debris retention basins can be provided on the upper cone.	
1.2 Debris flood torrents	Newtonian viscous mass flow without pulsating and blocking debris waves; velocities, impact forces, and transportation power with regard to large boulders smaller than in debris flows; debris *floods spread as flat blankets on torrent* cones and fans; they less steep originate in deposits of residual colluvium and fresh alluvial deposits ("Alt- und Jungschuttbäche" of Stiny 1931); water and debris load are thoroughly mixed as described by Thiery (1891).	Dangerous torrents (especially for poorly constructed houses); depending on the water content and velocity debris floods tend to spread over the whole fan or cone area; in view of the smaller velo*cities as compared to debris flows* check dams do not have to be provided with the debris flow discharge section ("Murprofil"), but wings and abutments of dams have to be of sufficient height.	2.4 - 3.0
1.3 Bedload torrents	Debris transport in a bedload "band" or "carpet", with only moderate amounts of fine - grained particles, accompanied by audible noise; aggradation along gentle reaches creates loss of gradient and channel braiding; debris sources of small volume or at a great distance from the generally flat debris fan.	Not as dangerous as debris flows and debris floods; damage due to aggradation, bypassing and erosion of bridge piers; bedload discharge follows established roads and channels down the fan (as in 1.2); a calculation of expected bedload determines channel works and size of retention basins along the torrent and its junction with the receiving river.	
	Floods carrying finegrained solids, which overflow and cause damage by deposition in low - gradient redepositional reaches; no debris fans develop.	Moderate damage, due to scour along of walls of buildings and in finegrained channel beds; lateral erosion; channel revetments and the development of "island" sites as counter measures.	

Fig. 1. Box - shaped cross - section of deposits of rapidly moving decelerating debris flow (Aulitzky 1970), observed in the Enterbach / Tirol / Austria

The most important consideration concerning a debris cone is whether it is active or fossil. With the progressive removal of a debris source or a reduction of debris potential in the source are the debris cone creases to grow and the torrent begins to disect its own deposits thus reducing the gradient of the channel.

The comparison of the old and the new torrent gradient in conjunction with a test on whether a flood event will affect the surface of the cone by breaking out of its new incised channel is of considerable significance in the torrent evaluation of "silent witnesses" (hazard indicators) on the cone. It is only significant with respect to "silent witness" (hazard indicators) to what extent an extreme flood event affects the new profile.

As a rule for practical work a recurrent design event of 150 years is used in torrent control in Austria; unfortunatly related flood control work is carried out with a different reccurrance interval (Bundesministerium für Land- und Forstwirtschaft 1972 and Republik Österreich 1976). The author would consider it preferable to uses the largest possible and recognizable flood event for areas of permanent settlements. Good discharge records are generally not available for torrents, but permanent communities ought not to be destroyed, today or tomorrow. This approach again makes use of the criteria listed above, including the thickness of debris layers, flood levels, and depth of erosional scour.

2. Genetic Classification Related to the Type of Erosional Processes in the Catchment Basin

The behaviour of a torrent on the debris cone is the integrated result of a variety of processes in the catchment basin including its size, the geological substratum, and the distribution of precipitation which may differ from one segment to another. The most important parameter is the geological substratum and its specific reaction to a variety of precipitation events. The character of a torrent may bei uniform with regard to its geology, hydrology and hydrogeology - but this need not be the case. Therefore the subdivision of torrents as to the type and trend of erosion in the source area may be relevant only for certain parts of the catchment basin (watershed). The classification proposed below is based on the types of erosion (vertical and lateral) induced by surface runoff and on the type failures embankment induced by subsurface water pressures and gliding layers. Further subdivision can be achieved as to natural and artificial release mechanisms. Stiny's (1931) concept to derive the mechanism of debris generation from features in the source area has been maintained, although only those mechanisms have been considered that are significant for a larger section of the catchment basin or source area.

In the attempt to characterize the mechanism of certain debris sources new words had to be introduced which might, on the first inspection, appear unusual.

2.1 Torrents with Erosion from Surface Runoff

These torrents can be subdivided into two groups: one group is characterized by erosion of the whole dicharge section with considerable depth scour (scour torrents); the other group is dominated by local lateral erosion due to concentration of isotachs along the outer channel bends (lateral erosion torrents). Both types may be represented in composite catchment basins. The first group is more dangerous than the second one. As to dominant grain size one could distinguish debris and mud torrents.

2.1.1 Scour Torrents (Torrents with Depth Erosion)

In these torrents the channel bed posesses insufficient strength to resist exceptional stresses (e. g. along reaches of high gradient) and thus cannot assure bed stability. The torrent strives to establish a balanced profile between the stable reaches approaching a hyperbola. The subgroupings differ by the character of the substratum.

2.1.1.1 Natural Scour Torrents

2.1.1.1.1 Colluvial Scour Torrents

Colluvial scour torrents are characterized by rapid and dangerous growth of scars with V - shaped cross sections. The process may affect long stretches of the channel and extend over considerable time intervals until general degradation and bedrock spurs combine to develop a balanced profile. The trend of erosion is towards a steady distribution of the erosional parameters in the sense of Sternberg's Law (1875) and in the sense of an equation for a longitudinal profile put forward by Hampel (1969, 1970). With the great or even excessive gradient of the bed as the principal genetic factor the scouring forces of the torrent exceed the shear resistance of the bed. Debris generation by downward erosion is the essential process of valley formation, requiring as typical counter measures check dams in stacked arrays.

2.1.1.1.2 Volcanic Scour Torrents

Volcanic debris flows originate along V - shaped scour ravines of volcanoes. The ravines may also guide intermittent lava forms. Complexities arise due to the intercalation of erosion - resistant lava and erodible ash deposits. The control of such composite scour ravines by means of stacked arrays of check dams is difficult because the foundations of transverse structures tend to set off continuous minor mass movements leading to the eventual failure of entire check dams arrays. During intense rain storms masses of water may combine with hot ash deposits to produce dense mud flows ("Lahar mud flows" in Indonesia). A more sandy matrix creates a less dense debris flow ("Baujir" in Indonesia or "Dosharyn" in Japan according to the Japan International Cooperation Agency 1979).

2.1.1.1.3 Bedrock Scour Torrents

Bedrock scour torrents are characterized by a very slow evolution because of the great resistance of bedrock channels to erosion, even along steep reaches. In general it is not worthwhile to control such torrents by engineering works.

2.1.1.1.4 Partial Scour Torrents

These are torrents which in general do not show characteristics of torrents, but possess reaches with substantial depth erosion. In Austria for instance the "Danube torrents" in Nibelungengau and Wachau which drop steeply from the plateaus of Mühlviertel and Waldviertel districts towards the Danube and Kamp rivers. Scour along these steep reaches is induced by the large discharge of water derived from extensive catchment basins on dense granitic terrain. Along torrential reaches erosion is limited to wege - shaped scour depressions below waterfalls and ravines.

The generation of debris along these torrents is limited and rarely exceeds a moderate volume. Measures against scour are confined to masonry revetments rather than stacked arrays of check dams.

2.1.1.1.5 Torrents with Strong Infiltration

Torrents with strong infiltration are limited to permeable terrain and / or high catchment basins normally. In the case of catastrophes the discharge and erosion decrease in a downstream direction, channels become narrower and occasionally disappear altogether. The geological substratum is predominantly fractured and stratified carbonate rock, talus, or permeable sands (e. g. "Wadis").

In the area of erosion stacked arrays of check dams would only help in exceptional cases. In the depositional domain diversion structures (dams and gabions) might aid the infiltration. Application of flood formulas abulutely have to be avoided in this type of torrents.

With increasing size of the catchment basin the amount of HQ may decrease (or stay constant). In addition discharge sections, flood levels, and cumulative debris load diminish and can best be evaluated in the field.

2.1.1.1.6 Gullies

Gullies produce mud flows along steep - walled channels in a generally gentle terrain. At the head of the gully material is derived from deeply incised walls from where it is carried to the mouth. Gullies are the result of extreme flood discharge and traction forces on poorly consolidated, fine - grained (often aeolian) channel bed materials. The abrupt incision at the head of the gully owes its origin to scouring of water into homogeneous packed fine sediment; stepped profiles develop in stratified deposits. Gully formation is particularly common in arid and semiarid zones (Heede 1980). Erosion is retrogressive and proceeds rapidly at the head of gully in times of extreme rainfalls (discontinuous gully).

In the uppermost parts of the gully system more gentle gradients are also found (continuous gully according Heede 1980). The evolution of gullies eventually tends towards extremely low gradients. It is therefore important to control the head of a gully and its branching network of tributary runnels. In the lower sections of a gully and on gentle fans damage arises mainly from mud accumulation. Due to the small grain size of the substratum buildings and control works are easily undercut or bypassed and have to be protected accordingly.

Gullies are also common where runoff from roads attacks loose side or where agricultural activity (corn, hops, vines etc.) uses too steep slopes with fine granular soils.

2.1.1.1.7 Debris - Accumulating Torrents (Stiny 1931)

In these torrent debris is accumulated "on call" along wider and low - gradient reaches - and can be remobilized during extreme events. Among debris - accumulating torrents in mountainous terrain there are transitional types towards free meanders and thus embankment erosion may supply part of the debris. Stiny (1931) pointed out that torrents characterized by such intervening depositional reaches tend to "clean" themselves in intervals of 35 years. Counter measures include provision of sufficiently voluminous debris retention basins.

2.1.1.2 Induced Scour Torrents

Such torrents develop due to artifical confinement of channel to the extent that its discharge section is unable to handle flood discharge. Confinement of channels may develop along forest - roads, haulage along topographic depressions, artificial increase of discharge or new water channels in erodible materials and extensive cultivation on formerly natural terrain. According to the geological substratum the resulting erosional forms vary (e. g. gullies in finegrained materials); transitional forms to torrents with lateral erosion exist. Counter measures include the establishment of a new erosional balance along the channel or a control of the disturbance.

2.1.2 Lateral Erosion Torrents

Under this heading fall torrents whose traction is insufficient to cause major depth erosion (scour) and whose activity is limited to lateral erosion due to a concentration of isotachs along the outside channel bends resulting in embankment erosion.

Lateral erosion may be the result of a forced directional change or that of free meanders along the valley floor.

2.1.2.1 Natural Lateral - Erosion Torrents

These torrents and their directional changes are determined by the lithology and structural geology of the underlying terrain.

They are found in mountainous regions where repeated changes in the direction of the valley impose bends and abrupt embankment breaks. Even the torrents of gentle terrain (Salzer 1886) which develop redepositional reaches rather than debris fans can produce embankment scars along shifting meander bends.

2.1.2.1.1 Torrents with Predetermined Channel Bends

These torrents derive their debris from embankments which are undercut during excessive discharge, thus endangering roads, buildings, and other cultivated terrain. Steep slopes may be converted into menacing sources of debris. The evaluation of hazard and evolution of a debris source has to start at the principal points of erosional attack - using vegetation as a guide. The development of debris cones or, more often, debris fans depends on the quality of erodible debris along the torrent. Technical counter measures include block - throw spurs, channel reenforcements, and, less commonly stone masonry revetments, check dams, channel cuts. In conjunction with embankment controls biological improvements should be carried out.

2.1.2.1.2 Torrents with Free Meanders

During the development of meanders in low - gradient valley reaches only finer grained materials are reworked. Accordingly, only fine - grained debris accumulate along the bottom of the valley during flood events. The main preventive measures include the exclusion of permanent settlements, careful industrial site planning and diking. Near existing settlements the development of safe "islands" with erosion - resistant block buttresses prevent excessive scour. Level and design of basements have to accomodate a design flood. Technical measures include channel straightening and flat sloped embankments, combined with biological techniques.

2.1.2.1.3 Grass - Scar Torrents

This type, proposed and reported by Stiny (1931) cannot be discussed in detail here. Grass torrents erode only a tenuous grass - soil cover which establishes itself in between flood events along the channel. The damage caused by this type is normally harmless.

2.1.2.2 Induced Lateral - Erosion Torrents

These torrents origniate by confinement of channels by roads. They may even evolve into scour torrents. Smooth embankment controls along roads may similarly increase the discharge velocities and thus increase the potential for scour and lateral erosion. Bridges and culverts with narrow cross sections tend to be blocked by drift wood and thus force channel abandonment.

2.2 Torrent with Embankment Failures

These torrents do not create their own debris but receive it from landslides (slope creep, slumps, conchoidal failures, earth flows, debris avalanches). Blockage by slide debris is the main hazard associated with these torrent if discharge is insufficient to carry away the accumulated material harmlessly. Dependent on the type of debris supply different segments of the torrent tend to pose different hazards and growth patterns. Sagging or creep of entire mountainsides tends to shift the torrent channel and thus set the stage for enormous debris flow potential. Similar hazards arise from bursting blockages of the channel caused by slide masses or debris flow from tributary ravines. Voliminous debris slumps and conchoidal failures (= "Muschelanbruch" by Stiny 1931) tend to be more dangerous than surficial planar debris slides. Large scale translation slides, however, such as those of the Jasnitzgraben /Allerheiligen / Mürztal / Styria / Austria, are exceedingly dangerous. Geomorphological tests (e. g. Moser 1973) may give an indication for the failure potential of embankments. Embankment failures can also be induced artificially by defective drainage works, insufficient storm drains, runoff from parking lots, ski runs etc. Remedial measures along the mountain sides include drainage, reforestation, stabilisation of slide debris, retaining walls, flexible check dams (Ofner 1977). debris retention basins and channel works.

2.3 Special Torrents

This group encompasses torrents with a great variety of erosional processes. There are connections with other types, but it seems better to divide for a better understanding.

2.3.1 Ice - Debris Flows and Snow - Debris Avalanches

Mixtures of ice and debris, and mictures of snow and debris can attain great velocities, as demonstrated by the ice - fall - debris - flow of Huascaran on May 31, 1970 (Welsch / Kienzl 1970), which descended with an average velocity of 250 to 300 km/h accompanied by extensive development of much dust and an airblast. Snow - debris mixtures, as they occur during springtime rainstorms (as in April 1975 in Lungau) are also dangerous because the saturation of snow and soil with water enables the avalanches to reach great velocity, jump their natural ravines, and ascend the opposite valley walls. Not only the flowing material but the airblast has destructive potential and is not governed the laws of hydraulics. The volume of erosion of these processes may be small; neverless they may carry large blocks of bedrock.

2.3.2 Karst Torrents

Karst torrents flow partly through cave systems, and thus experience a reduction of the flood wave. A diversion of Karst torrents into cave systems may reduce their damaging impact, as demonstrated by the "Katavotrone" (upward convex rakes) of the k. k. Wildbachverbauung in the old Austrio - Hungarian Monarchy.

2.3.3 Glacial Torrents

Glacial torrents are dominated by the concentration of discharge (and bedload transport) in the summer months. Debris that has been accumulated along a channel during the year is carried off in this short period of peak discharge. Coincidence of rapid snow - ice melt and thunderstorms may set into motion damaging masses of debris from the forefield of the glaciers. Such flood events are best countered by block throw dikes reinforced by internal cable systems to protect oversteepened banks and maintain a straight course of the channel.

2.3.4 Earthquake Torrents

Repeated earthquake activity in a certain region may add to the instability of bedrock slopes. Technical counter measures along torrents have to consider this specific parameter (Querini 1980). Historical sources and documentation of recent events are significant aspects of this approach. The direct effects of an earthquake (i. e. rock avalanches, torrent blockages, colluvial slides, and collapse of buildings) contribute to the phenomena along the torrent channels that are covered adequately by the classification parameters discussed above.

2.4 Composite Torrents

As pointed out in the introduction, it is not always possible to characterize an entire catchment basin with one parameter or one type only without creating a bias. Distinct segments of a torrent can be concisely described as to their torrent and slope dynamics - but the catchment basin may be a composite of different types identified along individual segments.

Therefore in contrast to the debris cone where processes are integrated into the image of an extreme event, the source area is characterized in the description of a composite torrent which is characterized by its individual segments.

2.5 Conclusions

The summarizing Fig. 2 gives an overview of the genetic classification, based on past experience and is probably subject to further testing and correction. Nevertheless it seems that with a view towards forest - management of catchment basins, and the application of active or passive measures on the cone, the five genetic categories of debris movement are an adequate beginning.

With regard to sheet erosion, a phenomenon transitional to rill erosion, view points and management practices are somewhat different (watershed management). In principle, damage arises from surface runoff which is considered in Fig. 2 (broken lines).

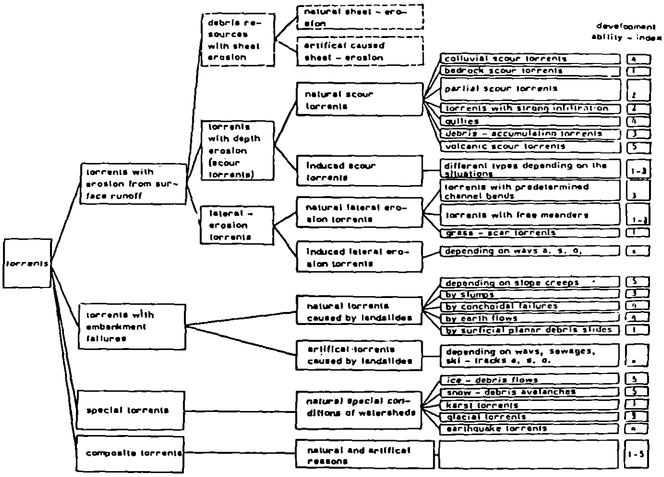

Fig. 2. Scheme of torrent classification inside the catchment basins and segments of catchment basins. Legend of the developing - index: 5 = very dynamic developing potential, 4 = dynamic developing potential, 3 = moderate dynamic development, 2 = small development, 1 = virtually stabile, x = different possibilities

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