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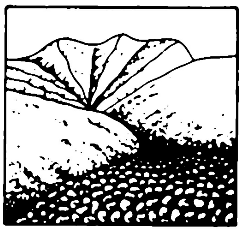

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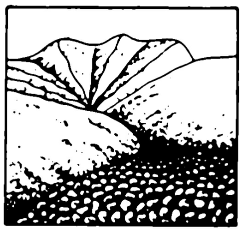

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При создании логотипа конференции использован рисунок из книги С.М. Флейшмана «Селевые потоки» (Москва: Географгиз, 1951, с. 51).
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About the mobility of debris flows using empirical runout prediction methods

C. Scheidl[1], D. Rickenmann[1,2]

[1] *Institute of Mountain Risk Engineering, University of Natural Resources and Applied Life Sciences, Vienna, Austria*

[2] *Swiss Federal Research Institute WSL, Birmensdorf, Switzerland*

О мобильности селей (с использованием эмпирических методов прогноза движения)

К. Шейдл[1], Д. Риккенманн[1,2]

[1]*Институт проектирования в горных районах, подверженных риску, Университет природных ресурсов и прикладных наук о жизни, Вена, Австрия*

[2] *Швейцарский федеральный институт исследований снега, леса и ландшафтов, Бирменсдорф, Швейцария*

Полуэмпирический подход, описывавший ход движения вулканических селей (лахаров), был применен для селевых потоков. В статье описано тестирование для альпийских селевых потоков в Южном Тироле (Австрия) и Швейцарии, а также сравнение с ранее опубликованными данными. Показано, что использованное эмпирическое соотношение также описывает ход потоков разных генетических типов и с разными условиями аккумуляции селевой массы.

A semi-empirical approach to describe the runout behaviour of volcanic mudflows (lahars) was found applicable to debris flows. Within this paper the method was tested on alpine debris flow events from Austria, South Tyrol (Italy), Switzerland and compared to published datasets. It is shown that the applied empirical relation also describes the flow behaviour of different process types and its characteristic deposition.

1 Introduction

The delineation of endangered areas is one of the most important tasks of an effective hazard zone mapping. For debris flows, snow and rock avalanches runout prediction methods are important tools for natural hazard assessment. For torrential processes, such as debris floods and debris flows, there is no simple and universal runout prediction method. There is a need to better understand and describe the depositional characteristics and runout behaviour of debris flows.

The transport mechanism of mass wasting processes in torrent catchments can be classified into fluvial, debris flow like, sliding, and falling dislocations (ONR 24/800, 2007). A general classification can be made depending on the relative concentration of water, fine and coarse sediment, as first suggested by Phillips and Davies (1991) (Fig.1).

Debris flows can be roughly classified due to the relative concentration of fine and coarse sediment by the prefix ‘viscous/muddy’ or ‘granular/stony’ to describe the main flow behaviour (e.g.: Takahashi, 1991; Coussot and Meunier, 1996; Ancey, 2001). Here the terms granular and viscous are used to distinguish between high and low flow resistance forces of the moving mass. This classification can also be used as an indicator for the depositional characteristics. Several approaches have been developed to specify the magnitude of the depositional area of debris flows. Due to improved event documentations and considerable quantities of published data, more information about debris flow events are now available.

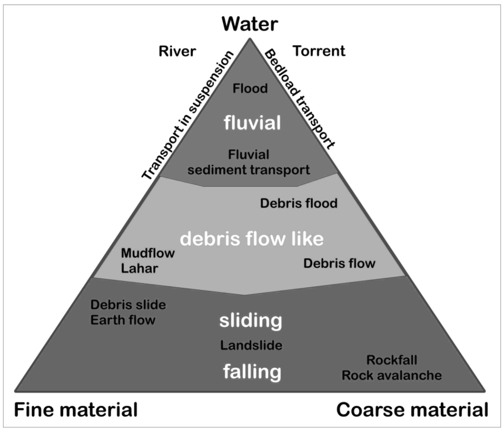

Fig. 1. Phase diagram of torrential processes (from Phillips and Davies, 1991).

The objective of this paper is to test the semi - empirical approach of lahars (Iverson et al., 1998) showing that the planimetric area (B) of recent debris flow events in Austria, South-Tyrol (Italy) and Switzerland is linearly correlated to the debris flow volume (V) on a logarithmic scale (equation 1). By comparing the recent debris flow events with published debris flow datasets, it is shown that the coefficient of the fitting equation,

$$B = k \cdot V^{2/3} \tag{1}$$

act as a significant parameter to describe the main expected flow behaviour (granular/stony – viscous/muddy) of debris flows.

2 Data collection

A first step of the investigation is the acquisition of data about past debris flow and debris flood like events. The main focus is on the deposition volume, deposition area and the shape of the debris-fan. For complementation also topological parameters and descriptions of geomorphologic features of debris events have been collected. Altogether 109 debris flows and 27 debris flood like events of Austria, South Tyrol and Switzerland have been selected for further work. For some Swiss debris flow events of 2005, high resolution digital terrain models derived from airborne LiDAR data are available to provide more accurate estimates of event volumes and depositional geometry.

Table 1 shows an overview of the used dataset within this study. The data of debris flow events in South Tyrol are provided by the department of Hydraulic Engineering of the Autonomous Province of Bozen (Dept. 30). The collected dataset of the debris flow events 2005 in Switzerland are based on the investigations due to the flood event 2005, analysed by Bezzola and Hegg (2007), whereas the events of 1987 were collected in VAW (1992). The Austrian debris flows, as well as debris flood like events, were collected by Schraml (2007).

3 Results and discussion

Based on the assumption of geometric similarity of debris flow deposits, Iverson et al. (1998) described a theoretical relationship between planimetric area and its deposited volume (see equation 1). Table 1 shows the estimated coefficients as well as the related coefficients of determination for our dataset and some published data. Figure 2 shows the empirical relationship between planimetric area B and deposited volume V obtained from all available datasets. Considering a constant amount of deposited volume, it has to be pointed out that an increase of results in an increase of the expected runout.

As shown in table 1 the coefficient ranges between 6 and 200 representing process types from granular debris flows (low values) to volcanic mudflows (lahars) (high values). The debris flow events in South Tyrol and Switzerland 1987 occurred in higher alpine regions with smaller catchment areas. We therefore mandate those debris flows a higher concentration of coarser material which characterise its granular flow behaviour. On the other hand debris flood, mudflow or lahar events have higher concentration of finer material and/or water (Fig.1) which implies a viscous or muddy flow regime.

Table 1. Overview of collected datasets.

study	process	region, area	number of collected events	coefficient k	coefficient of determination (R^2)
Crosta et al. (2003b)	granular debris flow	Alps, Northern Italy	91	6	0.96
this study	**granular debris flow**	**Alps, South Tyrol**	**55**	**18**	**0.66**
Griswold (2004)	debris flow	USA	44	19	0.91
this study	**granular debris flow**	**Alps, Switzerland 1987**	**34**	**28**	**0.76**
Yu et al. (2006)	debris flow	Xueshan, Taiwan	6	29	0.94
Berti & Simoni (2007)	debris flow	Alps, Northern Italy	24	33	0.80
this study	**debris flow**	**Alps, Switzerland 2005**	**8**	**38**	**0.43**
this study	**debris flow**	**Alps, Austria**	**12**	**45**	**0.72**
Capra et al. (2002)	earth slides and debris flows	Trans mex. Volcano belt	6	51	0.79
this study	**debris flood like**	**Alps, Austria**	**27**	**57**	**0.91**
Waythomas et al. (2000)	volcanic earth flows	Alaska	10	92	0.90
Iverson et al. (1998)	lahars	USA, Columbia, Philippine	27	200	0.90

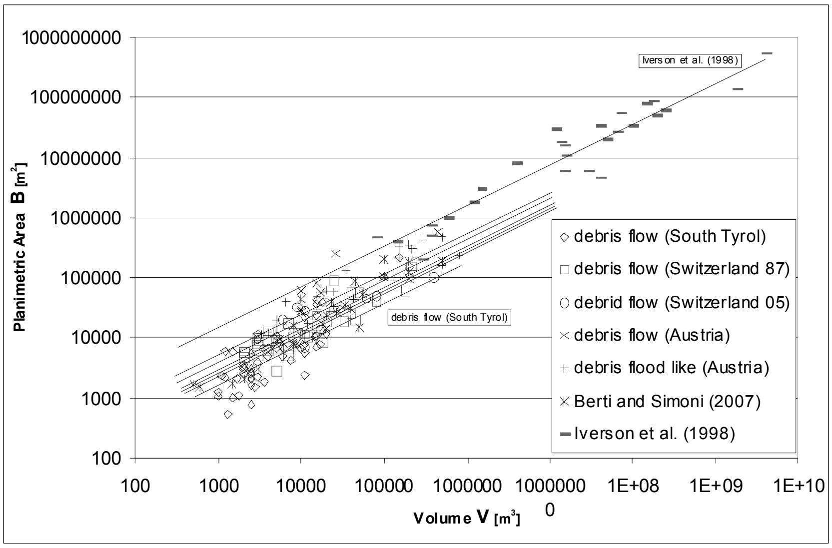

Fig. 2. Relation V vs. B using debris flows, debris flood like and published data, best-fit equation 1.

Figure 2 shows that an increase of the viscous or muddy characterisation of a debris flow is directly related to an increase of the runout prediction and vice versa. In other words, the shape of the deposition fan of granular debris flow events differs significantly from the shape of the deposition fan of viscous resp. muddy debris flows. A simple method to describe the shape of a debris flow deposition includes the fan slope. We suggest that granular flow behaviour will lead to a higher roughness during deposition activity, which further results in steeper fan slopes on average. A more viscous respectively muddy flow behaviour, on the other hand, will result in smoother fans. A rough confirmation of this hypothesis can be seen in Figure 3 using the dataset of Austria and Switzerland.

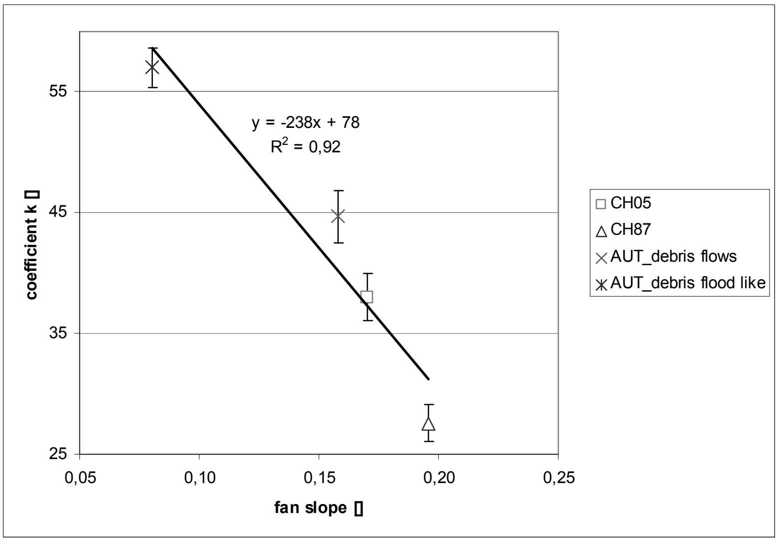

Fig. 3. Rough correlation between calculated coefficient k and fan slope of the debris flow dataset from Austria and Switzerland.

4 Final statement

The influence of material composition on debris flow deposition pattern was shown and we believe this has to be considered when using the semi-empirical approach as a runout prediction method on future events. However a detailed examination of the relation between the shape of a fan and the observed flow behaviour has yet not carried out.

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