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DOMODIS – Documentation of Mountain Disasters

State of Discussion in the European Mountain Areas

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DOMODIS
Documentation of **Mo**untain **Dis**asters

State of Discussion in the European Mountain Areas

Cover photo: Narenbach 1977, Diemtigtal, Switzerland (Kienholz)

Contents

Narenbach (Diemtigtal, Switzerland) Kienholz, 1977

DOMODIS stands for **Do**cumentation of **Mo**untain **Dis**asters. It is a joint ICSU-CDR[1]/IAG[2] project on mountain disasters with support by INTERPRAEVENT[3].

The project, initiated by Hans Kienholz, University of Berne (Switzerland) responds to the perceived needs for standardized documentation by local experts and geoscientists as well as a responsive organizational structure.

DOMODIS has been discussed in four international workshops:

- March 1998 in Bern, Switzerland;
- November 1998 in Barcelona, Spain;
- October 1999 in Bukarest, Romania;
- September 2000 in Goldrain, Autonomous Province of Bozen (South Tyrol), Italy.

The participants coming from different mountainous regions, but mainly from the Alpine countries in Europe tried to find a kind of **state of discussion** regarding this topic. In this paper we collected the basic contributions and ideas in order to deliver a survey regarding approaches in the European alpine countries about DOMODIS at the moment. We are quite aware of the fact, that this paper is only a starting platform for further discussion and experience exchange in future. In this sense we are looking forward to comments and contributions from other groups dealing with this subject. Nevertheless we will use the term „handbook" for this paper as an abbreviation. You will find the results of our discussions in five chapters:

- **Part 1** describes the general aims and objectives of DOMODIS and the framework for implementation.
- **Part 2** gives more information in detail aimed at the people responsible for implementation.
- **Part 3** is directed to the practitioners, in charge of the documentation work on site.
- In **part 4** you will find the references for part 1–3.
- The appendix in **part 5** is a collection of suggestions and examples for practical work (e.g. proposal for a map legend, form-sheets, examples, fingerprints etc.).

We thank all the colleagues contributing to this paper and of course all the participants in the workshops supporting the progress of this work in the discussions. In case of any questions, remarks or contributions please contact (german or english):

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- International Council for Science, Committee on Disaster Reduction, Paris (France);
- International Research Society INTERPRAEVENT, Klagenfurt (Austria);
- International Association of Geomorphologists, Vancouver (Canada).

[1] International Council for Science, Committee on Disaster Reduction (former ICSU-SC IDNDR), Paris (France)
[2] International Association of Geomorphologists, Vancouver (Canada)
[3] International Research Society INTERPRAEVENT, Klagenfurt (Austria)

1.1 Introduction

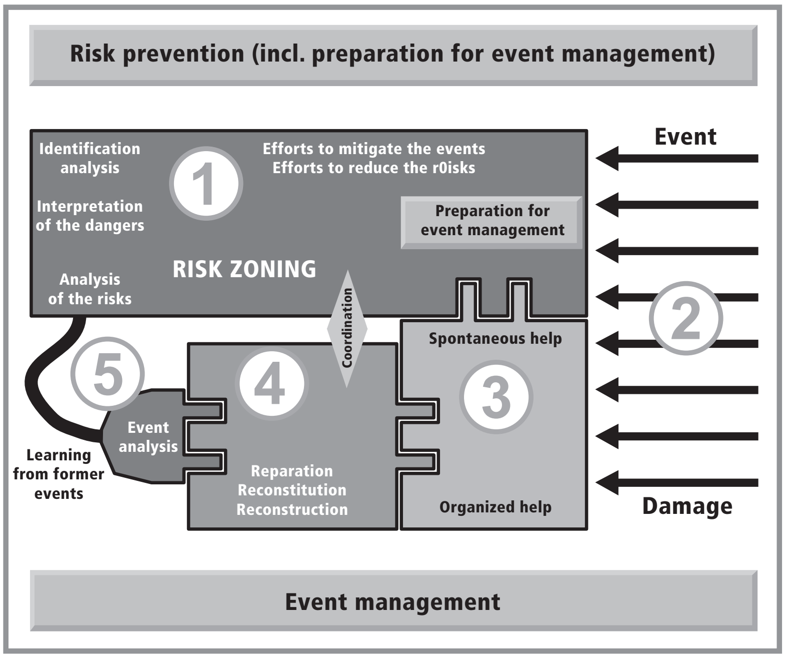
The management of mountain hazards and risks (due to snow avalanches, mountain torrents, debris flows, rockfalls, landslides, etc.) requires careful hazard and risk analysis and assessment. One of the fundamental approaches is to analyse former events, e.g. based on documents about such events. In order to do this and to enable or to improve such analysis in future it is absolutely necessary to provide such documents on occasion of actual events wherever these occur.

Because a lot of the information is not stored in an organized way we are presently facing the problem, that in many cases this documentation is stored only in the minds of local experts, inhabitants or archives. Needless to say as people retire these documents may become inaccessible or lost. Furthermore there is no consequent assessment of former events on a long term or regional level. So there is a strong need to implement a well organized structure for documentation and archiving of hazards.

This handbook deals with the **Do**cumentation of **Mo**untain **DIs**asters (DOMODIS). It provides information about the scientific and technical background, about the necessary organizational and technical framework. Thus it shows how DOMODIS may be carried out and how DOMODIS may be organized by a state or provincial government.

This handbook is about real-time/just-post-eventum **documentation** with form sheets, cartography and images. In the first hand it has nothing to do with hazard anaysis and/or risk analysis, assessment or management in an actual situation; this system will only provide data in a synoptic form for further use. In this sense the collected information is a valuable source for further information. Because the natural conditions and the political and administrative frameworks may vary very much all over the world, general proposals only and some illustrative examples are given. Based on the general ideas, in every single case the implementation must be adapted to the specific conditions.

Fig. 1 The risk management circle (Kienholz 2001).



1.2 Mountain Hazards and Risk Management

Mountain hazards are defined as the occurrence of potentially damaging processes resulting from movement of water, snow, ice, debris and rocks on the surface of the earth, which includes snow avalanches, floods, debris flows and landslides. These hazards are inherent in the nature of mountainous regions and may occur with a specific magnitude and frequency in a given region (UNDRO 1991).

1.3 Risk Prevention and Disaster Mitigation

Many mountain disaster losses – rather than stemming from unexpected events – are the predictable result of interactions between the physical environment, which includes hazardous events and the human system.

Therefore a modern strategy in dealing with mountain hazards is heading towards a comprehensive risk management. This strategy requires systemic approaches in planning and realizing concepts and measures. It is generally understood that risk management includes two main categories: **prevention strategies,** and **event and post-event management.**

In fact the **preparation** for event management must be part of the prevention strategies.

As it is the case for any kind of risks, mountain risk management includes prevention and preparation for event management. This is illustrated in **fig. 1.** In step 1 the risk systems (terrain, geology, geomorphology, climate, hydrology, man's activities and behaviour, land use, etc.), thus all important components and processes and their dependencies and interrelations must be analysed. Risk analysis is a continuous and iterative procedure in order to keep track on the changes and developments within the considered system.

Wherever risk is considered unacceptable, adequate measures must be taken. These consist of well known „active measures", that is, techniques which prevent the release of dangerous processes (e.g. avalanche defence structures, reforestation, etc.), to slow down the process (e.g. check dams in a river system), to divert the dangerous process (dams, walls, etc.).

Comprehensive risk zoning is aiming to prevent settlements, life lines, etc. to be installed in threatened areas, and it also may show where additional measures may be necessary. Despite the best and most comprehensive risk analysis and consequent measures there always remain residual risks. In order to deal with these residual risks efforts and measures (step 1 in fig. 1) also includes the preparation (organization, equipment, training) for interventions during and after events (steps 3 and 4).

Wherever there is no experience from former events the involved experts for hazard and risk analysis and assessment within step 1 fully depend on their knowledge and general experience about nature (physics, geology, etc.) and man (land use, action and reaction patterns, etc.) as well as from the adequate application of suited models: They depend on „forward directed indication" only (fig. 2).

However, if there are former events at the considered place, that are reported and **well documented,** the hazard and risk analysis and assessment gets strongly supported by this local experience. Thus, it is only step 5 in fig. 1 that completes the risk management circle. This important step, its preparation, organization, and its execution are the issues of the presented handbook here.

1.4 Importance of Documented and Considered Experience

Accurate and comprehensive hazard assessment as one part of integral risk management demands application of a full set of methods (fig. 2). Such sets include:

- predicting future events (i.e. forward directed indication like detailed evaluation of the situations in the terrain as well as application of models describing the processes), and
- evaluating former events (for ex. „silent witnesses" which are documents about former events in the terrain as well as the evaluation of written documents).

The predictive methods also depend on the experience gained through evaluating former events. It is impossible to work out good models without observations, monitoring and experience from real life situations. **Thus knowledge about former events is indispensable.**

Many hazardous events are „short-lived" (lasting minutes to a few hours only), while there may be a very long time-span (years, decades or even centuries) between two reoccurring events (see example in fig. 3). Hazard assessment usually has to take place during the calm phases between the spectacular and decisive catastrophic events. Thus, the expert has to be able to form very good pictures and models of the possible events. And he or she has to be capable of predicting realistic scenarios which could happen during these intense shortlived events; needless to say this has to be backed-up by hard data and facts gathered from former events.

This demands for good monitoring of the events themselves. However, in reality it is quite seldom that experts are present, where and when such events occur. Therefore it would be desirable that those people, who are close to the event would monitor the processes and collect data, and that experts become alerted immediately to collect data during the event or, at least immediately after the event. Immediate measures like removal of debris from roads usually are taken **within a few hours.** Therefore important silent witnesses are removed in the runout and sedimentation zones of the disastrous processes.

The desire mentionned above however is not realistic: Inhabitants of the disaster area are fully engaged in rescuing and protecting life and goods. Also the experts and officers of the local governmental authorities are involved with rescue operations and immediate measures. People that incidentally try to document some aspects of the event (like local eye-witnesses, tourists or journalists) usually focus on the damage but not on the geomorphic process itself.

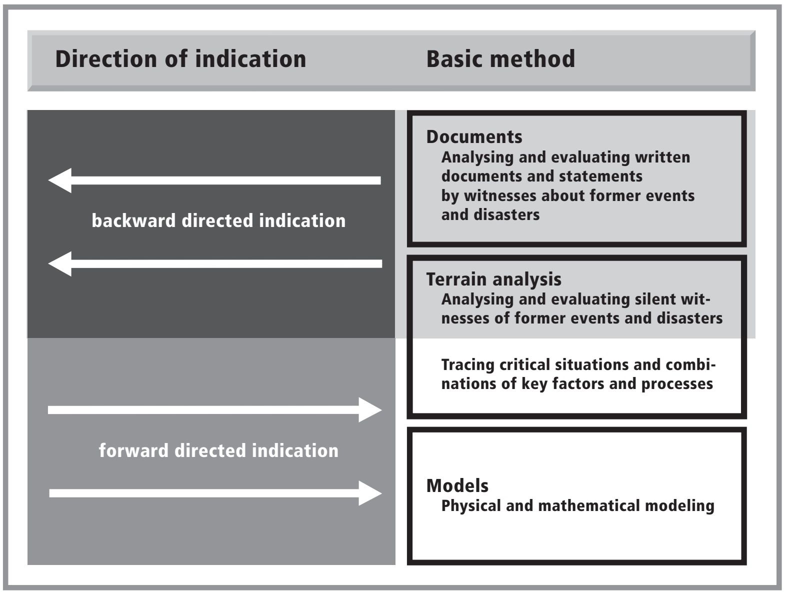
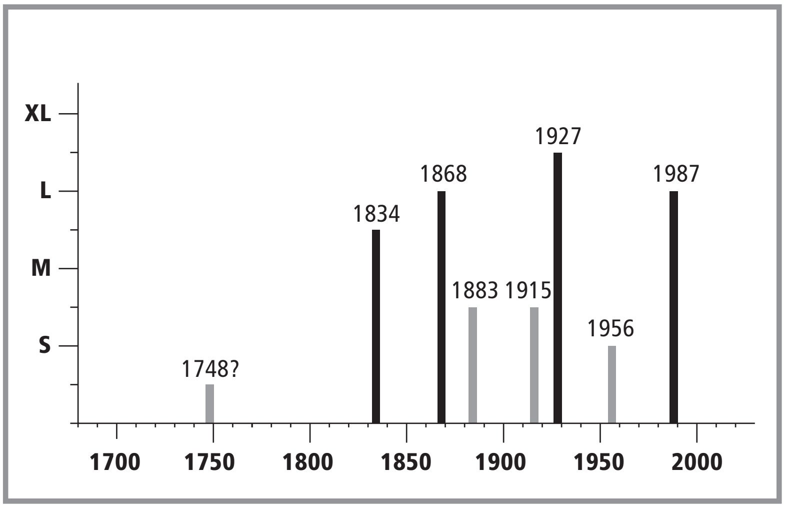


Fig. 2 Basic methods of hazard assessment (according to Kienholz in Heinimann et al. 1998: p. 55).

Fig. 3 Catastrophic torrential activity and debris flows affecting the debris fan of the Zavragia river in the Grisons/Switzerland (according to Kienholz in Heinimann et al. 1998: p. 52). Magnitude of event (transported bedload): **S**mall, **M**edium, **L**arge, e**X**tra **L**arge. Events larger than medium (M) size are indicated as dark bars, smaller ones as light bars.



1.5 What Kind of Events are DOMODIS Events?

Geomorphic processes occur anywhere at anytime: Water is flowing and weathering, erosion at small scales, transportation, and deposition of soil materials, etc. continues. However one issue of DOMODIS are those events that are of an important magnitude, that may cause either:

- damage to man and/or valuable goods;
- damage to vegetation and ecology;
- changes of landscape and ecosystems;
- reduction of performance of technical construction works.

Most of such events last only a short time (minutes, hours, few days); some other processes characterized by large masses, but slow velocities (e.g. deep seated landslides or rock creeping) may be continuous, periodical or episodical (years, decennials, centennials). However the documentation of the latter is less critical; thus DOMODIS mainly has to concentrate on the short lived events.

Besides the processes mentioned above DOMODIS also includes all different event types, even small in extent, not damaging events, that are able to provide information about processes, and about how well protective measures (e.g. defence structures) worked. Those events, that affect man, his goods and infrastructure require optimized event management.

Within a sustainable event management it is essential to include all available information of past events with or without respective damages as well as of current processes. How this documentation of the event can be integrated into the event management is outlined in the following.

In this context also the evaluation of historical data in archives of communities, authorities, monasteries etc. might be a helpful tool for a better assessment of hazards in a given situation. But this is not part of this paper.

1.6 Different Contributors; Various Interests

There are different contributors and customers, who are interested in various data about triggers and conditions of hazardous events and the relevant processes. Those people involved in the event management need actual data and first survey information.

On the other hand specialized scientists would like to gather very specific data about those aspects of processes they are especially interested in. And in between are the hazard experts and practitioners (e.g. civil engineers, forest engineers, etc.), from governmental agencies or private companies who are involved in any kind of mountain risk prevention.

The profound and specific data required by specialized scientists must be gathered by themselves, even if this is only possible some time after the event. For them it is essential, that they are informed as soon as possible about the event and that they will have access to the data already gathered by the other contributors.

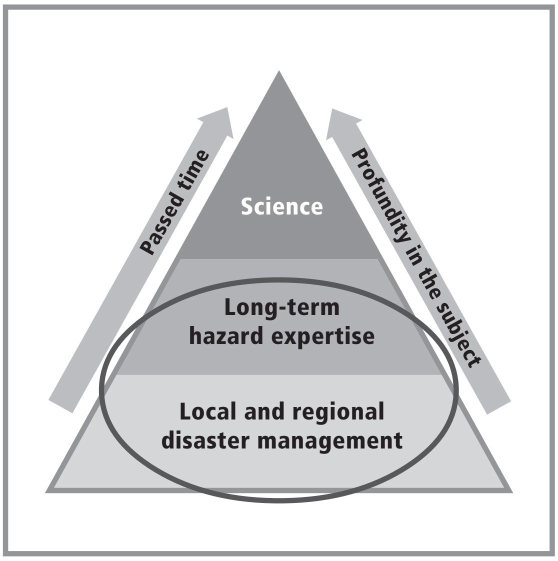
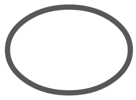


Fig. 4 Actuality and profundity of event documentation: interests of different contributors (Kienholz, 2001).



Range of DOMODIS

For the contributors, who are involved in event management the time factor is crucial. Thus they need quick and accurate information but they do not need all the information about details concerning the processes. Here the information is to be gathered by those people who are on the site.

DOMODIS is mainly focussing on the lower and partly on the medium category of contributors who require quite sound data that should be gathered during or very soon after the event. This involves data that are profound enough and reliable for hazard zoning and for the conception and design of future preventive measures and also for preparation for possible future events.

1.7 Organization and Training at a National, State or Provincial Level

In order to implement DOMODIS it is necessary to install a comprehensive administrative (even legal) framework at a national, state or provincial level.

The organization of DOMODIS in each country and province depends on various conditions, such as divisions and duties of the various governmental agencies, availability of (own) experts in case of event, availability of private experts, practicable financing procedures, financial restrictions, etc.

Event management on national, provincial or municipal levels includes many different activities that should be based on well prepared organizational structures. Many of the considered events, depending on the type (table 1) require the triggering of very well prepared as well as of ad-hoc activities. Such activities are for example:
- communication between all involved contributors;
- rescue of human lives;
- reconnaissance trips (flights);
- removal of debris;
- regulation of life lines (roads, railways, energy supply);
- warning systems.

Additionally to all these and many other tasks the event documentation must start as soon as possible after occurrence.

The monitoring and documentation of the event must be carried out by experts who are not involved themselves and who are not in charge of rescue measures.

To facilitate such documentation two major demands must be covered:
- Experts that can be called in case of events, must be instructed in a way to be able to provide such documentation in a standardized way and with the necessary grasp of the subject. This instruction is a part of the preparation of event management.
- An organizational structure must be provided,
  - •• that allows to call such experts and to co-ordinate their actions;
  - •• that supports the documentation by other appropriate means as to guarantee free access to the sites (e.g. by an official permit), to offer transportation, to arrange to take air photographs;
  - •• that guarantees the compilation, archiving of, and the free access to the collected data; and
  - •• that guarantees the basic funding of these actions.

It's an essential part of the implementation of DOMODIS to keep in mind the necessary training of the people in charge of the documentation work. It's also indispensable to provide proper tools for the documentation work in order to facilitate the work on site and also to ensure an equal level of quality of collected data.

1.8 Consequences for Decision Makers

The remarks mentioned above should emphasize the intention of DOMODIS and it's importance. All the experts participating in the four workshops and in the elaboration of this paper completely agree, that DOMODIS is an indispensable part of risk management in mountain areas. Some of the countries involved in the discussions have already started first steps for the implementation of DOMODIS. In this sense we consider this paper as a summary of the state of discussion in the European alpine countries. It might be valuable information for all other organizations dealing with this problem.

The implementation of DOMODIS requires some fundamental decisions:
- acceptance of the importance of DOMODIS;
- provision of necessary organizational and legal structure;
- guarantee of basic funding.

Under these conditions DOMODIS can be a powerful instrument in the framework of risk management in a preventive sense and also an important base for further development of our knowledge about complex natural processes.

Moschergraben (Austria) Hübl, 1997

Ötztaler Ache (Austria) WLV Osttirol, 1987

2.1 General Remarks

Each country or province must organize its own documentation structure depending on the administrative background involving experienced experts with different professional background and sound experience in terrain-work. The development of an appropriate structure involves:

- to define the goals and limitations of DOMODIS implementation within the considered territory;
- to define the organization of data gathering;
- to define what categories of persons should be on duty with DOMODIS: Members of the central administration? Road inspectors? Foresters? Experts from private companies? Others?
- to (re-)arrange the necessary tools for the individual territorial situation, such as illustrated examples, form sheets, map legends;
- to describe the documentation work;
- to organize links with "external data" (meteorology, historical archives, witnesses, photo and media material, high-urgency-actions and costs, control measures and costs, damages, etc.);
- to build-up data-base and GIS (Geographical Information System);
- to organize a service-/information center to collect, archive and disseminate information about events, dangers, risks, control measures, prevention modelling, etc.;
- to arrange input and verification of the data, output organization etc.

2.2 Insertion of DOMODIS into Risk Prevention and its Affiliation with Event Management

As illustrated in fig. 1, the documentation of hazardous events must be an integral part of risk prevention and closely related to event management. That's why it is necessary to pay some attention to this aspect in all planning and preparation of event management. This means:

- to integrate the responsibility for documentation in all organization schemes for crisis staff and other relevant organizations for example;
- to put the category "documentation" into all relevant check-lists and procedure forms of crisis staffs and civil rescue teams, etc.;
- to prepare permits for free access to the persons on duty with documentation and to support them (e.g. with transportation) with adequate priority.
- Event documentation must be perceived by all persons involved as a very important task in close relation with event management.

Table 1 Proposed classification of events: what are DOMODIS events? (Kienholz, 2001).

DOMODIS event: documentation in any case	**Conditional DOMODIS event:** documentation also depending on the other criteria	**Chronicle event:** registration of major parameters only (date, time, etc.) may meet the requirements

Affected area	**A3** region		**A2** community, town		**A1** single place	
Event frequency at the considered location/reach	**F6** first time observed	**F5** rare (recurrence interval >100 y)	**F4** medium (recurrence interval 30–100 y)	**F3** frequent (recurrence interval 5–30 y)	**F2** very frequent (recurrence interval 1–5 y)	**F1** several times per year
Magnitude of event	**M3** damaging event		**M2** nearly damaging event		**M1** important none damaging event	

Example A1 – F3 – M3:
single place event – frequent – damaging

As a general rule of thumb the field-work of phase 1 per event will require:

- **single place events:** 1 person-day (e.g. 1 day work for one person)
- **community, town events:** 5–15 person-days (e.g. 1 week work for 2–3 persons)
- **region events:** >20 person-days (e.g. >1 week work for >4 persons)

It may depend on the category of event what expenditure of time and costs really is necessary and possible. It is up to the responsible governmental administrations to decide this. However it is to be considered that very often the costs for good documentation are even less than one percent of the costs for rescue, clearance, restoration, and the eventual mitigation measures. Very often the expenditures for mitigation measures are better staked if the events are carefully analyzed.

2.3 Definition of Goals and Limitations of DOMODIS Implementation within the Considered Territory

Depending on the situation in the considered country or province it has to be defined which types of events are to be documented. This includes the following questions:

- What process types are occurring?
- What magnitude of events have been observed?
- Which locations were affected: Just major settlement areas? Life lines? All traffic routes? The whole territory?
- What else has to be considered?
- What type of work and in which extensiveness is required under which circumstances?

2.4 Classification of Events and Documentation Phases

There are different kinds of events. With respect to priority and recommended procedures for documentation there are – besides of the type of process – mainly three parameters to be considered: **magnitude of event, event frequency** and **affected area** (damage).

Depending on the general situation in a country or province, on the organization and on the availability of personal resources the responsible authority for DOMODIS may decide to modify the proposed criteria in table 1.

Depending on the dimension of the event and the requirements of different end-users (fig. 4) there may be 1 or 2 (or even 3) documentation phases:

- **Phase 1:** Just collect the minimum data (What? Where? When? How much?).
- **Phase 2:** Detailed study of the whole process area (e.g. catchment of a mountain torrent) will be necessary (experts).
- **Phase 3:** Very detailed and in-depth study about special aspects of the event. Such studies usually have to be done by the scientists and engineers themselves, but in close connection with the responsible authorities.

2.5 Organization of Data Collection During/After the Event

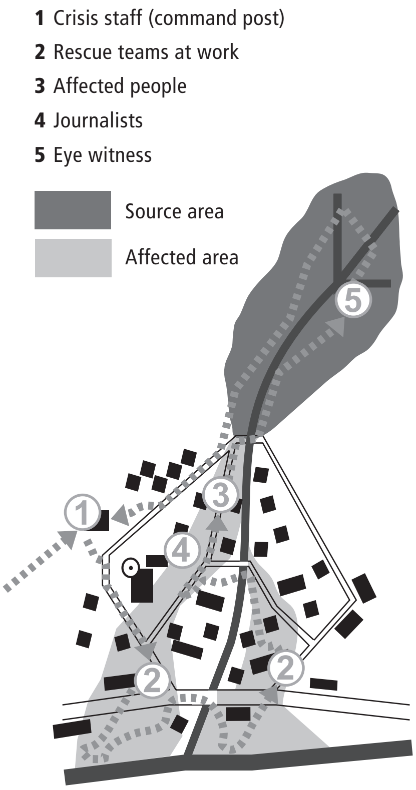
The purpose of first time documentation is to provide data for the event managers (e.g. for better safety for rescue teams, etc.). However, its primarily purpose is to collect all the important data for the lower and partly the medium category in fig. 4 (long-term hazard expertise), that is for the engineers and other professionals who are in charge of reducing future risks.

Therefore this kind of documentation must be carried out by people of the same profession and with the same education, thus by engineers, geologists, geomorphologists, etc. However this also must – in the beginning – include local (e.g. non academic) professional people (such as foresters, road foremen, linesmen, etc.), who are well instructed and trained in this work, and who may provide much better and reliable local experience. However, for the needs of the medium category in fig. 4 it is usually necessary to involve engineers, geologists, geomorphologists, etc. to refine and to supplement the observations and first interpretations. There are mainly the following issues to be considered:

- Who, in case of event, usually is alerted first? Is it any competent authority or office (e.g. police) where such information arrives in any case?
- After being alerted, who will be first on duty?
- Who is responsible for documentation (e.g. governmental officers, or experts from private companies)? Who decides about the further steps?
- How can this be integrated into the organization schemes of immediate risk prevention and event management?

Thus documentation must be provided by people, who know the needs of these engineers and other professionals; who understand the processes as well as the miti-

Fig. 5 DOMODIS as an independent part of event management (see also fig. 1). Arrows show an **example of "ideal path",** the sequence of activities and the contacts of the DOMODIS expert in the disaster environment that consists of:
- the disaster itself (natural environment after the disaster, destroyed objects, etc.), and
- the various contributors (crisis staff as focal point of all rescue activities and major partner of the DOMODIS expert).



Map of a village (buildings and streets) situated on the debris fan of a small mountain river.

Scenario: During a heavy rainfall the mountain stream originating in its upper watershed (greenish area in the upper part of the map) has left its bed at the uppermost bridge as well as at the second bridge. Parts of the village are covered by debris and mud; there is much devastation, some people are injured, some buildings are heavily damaged, and the streets are partly destroyed.

The crisis staff in its headquarter **(1)** is already at work.

Rescue and clear teams **(2)** are providing sanitary assistance, searching for injured and missing people, and already starting to remove debris.

Affected people **(3)** also have started to remove debris.

Several journalists and TV teams **(4)** are trying to get first hand information and sensational photographs.

A shepherd **(5),** as example, is somewhere in the upper catchment.

gation concepts and techniques, and who "speak the same language". Therefore as one part of preparation for DOMODIS (preferably as part of the preparation for event management) a regional (provincial) list of experts for documentation is indispensable. This list must be actualized periodically.

The checklist and organization chart prepared for event management should include the item "to call in specialist(s) for documentation".

The specialists for documentation must dispose of the knowledge, experience, and the necessary basic documents (forms, mapping legend) to do their job. They must be able to work more or less independently from the other activities of event management, but they must be in close contact with the event management staff.

The **principle of procedure** is indicated in fig. 5. The DOMODIS expert should be called by the crisis staff **(1)** or by local or higher level authorities. In any case, the DOMODIS expert contacts the crisis staff first **(1).** With a mandate or at least with the approval of the crisis staff and eventually also with some specific instructions the expert is responsible for the documentation with first priority at those places (usually impact zone) where remedial works have already started; e.g. removal of debris **(2).** The expert may also inspect other parts of the process area; e.g. parts of the relevant torrential catchment; making interviews with eye-witnesses **(5).** This is for example to better understand the causes and the course of the event but also in order to assist the crisis staff **(1)** in making decisions about necessary safety measures to protect the rescue and clearing teams **(2).** Having done this the expert reports to the crisis staff **(1)** exclusively.

The expert is not supposed to give any interviews to TV, radio and newspaper reporters **(4).** Interviews with journalists/press/media is the duty of the **crisis staff,** and not of the documenting person. Of course, the crisis staff may ask the DOMODIS expert to assist them in the media information issue.

Depending on the situation the expert may do further documentation work, still as part of phase 1 (table 1).

2.6 Data Management – Storage, Maintenance and Dissemination

Data collected by documenting and mapping damaging events have to be stored appropriately in order to provide them quickly for future planning and work. Therefore it is very important to decide how the data are to be stored, who is maintaining the data base and how the data access can be organized. First of all, unaffected by the applied technical means an able data-base structure must be selected or created. It is to be considered, that the data will be used for decades. Their life span corresponds to several generations of hard and software. That's why the emphasis must given on the organization of the data.

At state level it is to determine certain minimum requirements and to provide the basic structure of the data-bank. This structure should allow adaptations and completions at regional or municipal levels. The structure and organization of such data-bank should enable:

- to document confirmed hazardous processes and events;
- to keep – with first priority – full registration of events threatening important areas (e.g. settlements, major roads etc.);
- to keep the recording at a long term with a reasonable expenditure of time and costs;
- to gather the data, either non-central by instructed local experts, or – depending on the situation – also by external experts (from private companies, universities, etc.), or by close collaboration of both;
- to provide reliable data for hazard and risk analysis and assessment;
- to analyse event data at regional and supra-regional (e.g. national) levels.

The goal of the data-base is to provide information on historical, mostly damaging events. Emphasis must be given on the type and conditions of triggering processes, the controlling factors of the occurring process (vegetation, geology, meteorology, terrain conditions such as slope angle, aspect, etc.) and on the process itself including all specific characteristics (e.g. velocity of movement, volume, frequency, etc.), the effect (inclusive affected area) as well as possible damage. Based on that data-base the following minimum request can be obtained:

- correct distinction of the various process types;
- frequency of the considered process at the affected locations;
- effects of the process in the affected area(s);
- origin(s) and track(s) of the process;
- damage (to persons, mobile and immobile goods, infrastructure, nature, etc.).

Data about hazardous events typically refer to defined places or areas. Therefore the data-base has to include some geographical information. This may be done – also in future – by well established mapping methods (e.g. handwritten numbers in a paper-map). It also may be done by applying any Geographical Information Systems (GIS). If GIS techniques are used, each data information has to be geo-referenced, The main advantage of such techniques are the analytical capabilities of this system. Independent on type of storage, it should fit with the philosophy and the customary infrastructure of the responsible governmental organization. The most important criterion to be considered is to provide an open system, that can be adapted to future needs and possibilities.

It's also very important to define the format of the storage at the very beginning (e.g. tables in ACCESS or GIS-data).

After data collection and storage in a data-base, the information must be legally and technically accessible. Therefore the rules about disposal and use of the data must be defined.

2.7 Tools for Recording

For accurate and concentrate recording in a disaster area, in a stress situation under circumstances that require swift procedures, etc. it is helpful or even necessary to rely on accurate tools. Thus in a long-term preparatory stage it is necessary to provide such tools, to test already existing tools and adopt them to local/regional circumstances, to instruct the relevant persons etc.

It may depend on the organizational situation what tools are necessary and helpful for event documentation. In the field these may include:

- checklists;
- form-sheets for basic information[1];
- map legend[1];
- illustrated examples[1].

In the field sometimes it is more practical just to use simple checklists rather than to apply sophisticated forms. The goal – first of all – must be to gather all uppermost relevant information. The forms in this case are to be filled as the second step.

2.8 Instruction, Training of the Responsible Staff on Site

All persons that will be on duty with data gathering – e.g. road inspectors, foresters, experts from private companies, etc., (chapter 2.5) – must carefully be instructed. Besides the technical issue these instructions also have to deal with security! The experts doing documentation must maintain all adequate safety measures: They should not endanger rescue people (e.g. by triggering rockfall while crossing an unstable slope) nor themselves (e.g. sinking into the mud of a debris flow deposition or secondary follow up slides) in any immediate hazard. This includes informing the responsible rescue people about the planned paths and routes in order to fulfil the documentation purpose, etc. (e.g. **(2)** as shown in fig. 5).

The aims of technical and specialist DOMODIS instructions are:

- to make the recording experts aware of the importance of their documentation work;
- to enable the recording experts to document mountain disasters in a way that all relevant data are collected;
- to ensure that recording is done in a standardized way;
- to ensure that data fulfill the requirements of the end-user.

To achieve these goals it is essential to evaluate carefully the educational background of the recording experts. These experts may be road masters, foresters, technicians, engineers, etc.

[1] Examples see appendix

The first course (for example 1–3 days) includes **theoretical and practical parts.** On occasion of periodical (e.g. biennial) workshops with practical exercises the DOMODIS experts can exchange experience, and also mutual calibration of analyses, methods, criteria, procedures, etc. is possible.

The number of participants in the practical part should not exceed 5–6 participants per instructor. The instruction in the field should be well prepared in advance. By checking the quality of records of the events the success of the training can be evaluated periodically by the responsible officers within the administration.

Theoretical Course. The success of the theoretical courses highly depend on comprehensible illustrations such as video sequences of processes, photos of characteristics, etc. The form-sheets must be explained in detail: The meaning and the filling-in-rules for each field must be instructed carefully (are these nominal data? ordinal data? or metric data?; etc.). The theoretical course includes:

- instruction about the goals and importance of event documentation;
- relevant hazardous processes (common terminology) and their characteristics;
- relevant events for documentation (chapter 2.5, 2.6);
- elements of the work done by the staff involved and hints for appropriate equipment;
- safety aspects of field-work;
- explanation of the tools (chapter 3.1);
- organization of data collection, data handling and data transfer.

Practical Course. The practical course includes:

- priorities in field documentation;
- recognition of the characteristic phenomena of the processes in the field;
- mapping exercises;
- exercises in finding the relevant sites for measurements;
- measuring exercises (indicators about intensity of the process, e.g. cross-sections of a debris flow channel, thickness of sediment deposits, height of dents in trees produced by rockfall impact, etc.; and
- how to take photos (e.g. scale; documentation of the photo: position of photographer, direction of view, etc.).

Control and Sustainability of Training. The quality level of the courses has to be ensured continuously. This can be done in different ways:

- check of completeness of collected data;
- check of plausibility;
- repetition of training courses;
- consideration and discussion of experiences of the staff working in the field.

3.1 Tools for Documentation

It is wise to prepare a "tool-box" for the documentation work on site for several reasons:

- in the hectic of a hazardous event important items might be simply forgotten;
- for comparison and assessment of events on a regional level it has to be ensured, that collected data have the same structure and quality level;
- people on site should have a clear guideline of what they have do.

3.2 Checklists

For the people in charge of documentation it will be helpful to have a checklist of what they have to do. In this checklist following aspects may be organized:

- What is to be done and in which order?
- Which experts (names, phone numbers) are to be informed?
- What tools are available? Where to find them?

When preparing these checklists one has to keep in mind, that the people experienced in documentation work may not be available, ill or on holidays. Even in this case data collection must be ensured, perhaps on a reduced level.

3.3 Formsheets

The purpose of form-sheets is to organize documentation of natural events in a way, that the recorded data are comparable with data of other events. They should be the base of a characterization of catchments and/or regions and an assistance to enlarge the knowledge of processes in these regions.

The aim is to get as much information as possible about an event without endangering the documentation experts. The primary work is therefore restricted to the affected depositional area or to non-dangerous parts of the area in order to obtain "vanishing informations" (limited to the essentials).

When designing form-sheets priority must always be given to the "just in time-post eventum" data which might be lost within the first few hours or days. Moreover do not ask for data, which can be collected later in a better quality or hardly be answered by the person on site. Examples for formsheets:

- **Amount of damage in housing areas.** How should people on site answer this question during or immediately after the event? This may be part of a second step documentation.
- **Intensity and duration of precipitation.** In some countries there is a fairly dense system of gauging stations for precipitation. So it's no problem to get these data afterwards may be even in a higher accuracy when a combination with weather radar is possible. Another question is the type of precipitation – rain, snow or hail. This has to be documented on site. If available also data from private stations are of interest.

So form-sheets should be restricted to the essential informations, which are lost within a short time like:

- What has happended, type of event?
- When, date and time?
- How much in volume of discharge, debris flow, wood debris?
- Deposition zones, flooded areas?
- Significant influences like clogging of bridges, failure of construction works, if possible in the right order (what happened first, second etc.).

In the discussions within the DOMODIS-group it turned out, that the Swiss approach might be an effective concept for the design of form-sheets. In the **appendix** you will find a description in detail.

COMCAT (1996): Katastrophenschutz. Übersichtsblatt der Zentralstelle für Gesamtverteidigung, Swiss Federal Administration, Berne

Crozier, M. J. (1998): Landslides. The Encyclopedia of Environmental Science

Cruden, D.M., Varnes, D.J. (1996): Landslide Types and Processes. In: A.K. Turner and R.L. Schuster (Editors), Landslides: Investigation and Mitigation. National Academey Press, Washington, D.C., 36-75

Dikau, R., Brunsden, D., Ibsen, M., Schrott, L. (Editors), Landslide Recognition. John Wiley&Sons, Chichester, 1-12

Egli, T., Bart, R., Gaechter, M. (1997): Anleitung zur Spurensicherung. Kantonaler Ereigniskataster Naturgefahren, Naturgefahrenkommission des Kantons St. Gallen

Hegg, C., Bründl, M., 2002 (in prep.): Die Bedeutung von Ereignisanalysen, aus: Risiko+Dialog Naturgefahren, Tagungsband Forum für Wissen 2001, WSL, Birmensdorf

Kantonsforstamt Glarus (1998): Anleitung zur Spurensicherung. Kantonaler Ereigniskataster, Glarus

Mani, P., Zimmermann, M. (1992): Dokumentation nach Unwetterereignissen: Vorschlag für eine Anleitung. Interpraevent 1992, Tagungspubl., Bd.3: 121-130. Forschungsgesellschaft für vorbeugende Hochwasserbekämpfung, Klagenfurt

Melching, C. S. (1999): Economic Aspects of Vulnerability. Comprehensive Risk Assessment for Natural Hazards. World Metereological Organization, Geneva, WMO/TD 955: 66-76

Munter, W. (1991): Neue Lawinenkunde. SAC, Bern

UNDRO (1991): Mitigation Natural Disasters. Phenomena, Effects and Options, United Nations Disaster Relief, New York

In the appendix you will find a collection of suggestions and examples for practical work as we found it in the discussions in the workshops.

5.1 Proposal for a Map Legend

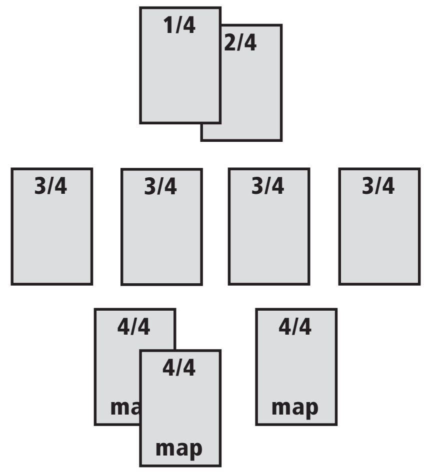
A generalized map legend is an important base to ensure a comparable data collection.However, this documentation work is more related to phase 2 of documentation, nevertheless it's an important tool to bring information on a comparable scale. The attached proposal for a map legend – originally proposed by Geo7, Berne (Switzerland) – refers to a scale of 1:25 000:

Torrent	red	Erosion
	red/black	Erosion on outcropping bedrock
	green	Erosion and sedimentation (rearrangement)
	green	Sedimentation
	green	Sedimentation on alluvial fan/debris cone
	red	Lateral erosion
	green	Coarse boulders in the channel
	green	Organic sediments (drifted timber) in the channel
	red	Flooded forest
Debris Flow/ Mudflow	purple	Erosion
	purple/black	Erosion on outcropping bedrock
	purple	Erosion and sedimentation (rearrangement)
	purple	Head of debris flow
	green	Debris cone (by debris flows)
Flood	blue	Flooded area
Landslide	brown	Scarp of landslide
	brown	Foot of slipped mass
	brown	Small landslip
Debris slide		Scarp of debris slide
	purple	Erosion by debris slide
		Area of sedimentation
Rock fall	black	Head, scarp, source area
	black	Area of sedimentation
Supplementary signatures	black	? Interpretation uncertain (e.g. differentiation between former and recent traces)?
	black	Area affected by several processes (not all phenomena can be mapped)

5.2 Form-Sheets (Example: StorMe, Switzerland)

StorMe, coordinated by the **Swiss Forest Agency**[1] (Swiss Agency for Environment, Forests and Landscape, Berne), is primarily a data bank system that provides a unified structure of documentation and storage of the information about natural hazards. The system also includes a set of form sheets in order to make fieldwork for documentation easier, and to systematize it:

The principle sequences of applicable form-sheets in the Swiss StorMe system:



This system includes several levels of documentation:

- a master record: form-sheets 1/4 and 2/4; general information about what, when, where, general problems for any event;
- Form-sheets 3/4 and 4/4 give detailed information about the main processes snow avalanches; rock fall; water, debris flow, landslide.

All important statements on the form-sheets must be qualified by the **MAXO-code.** The principle of this code is the idea, that any information is valuable, even a questionable guess is better than no information at all. So indicate the reliability of data in this MAXO-code which means:

M = measured data;
A = estimation of data;
X = not clear, to investigate;
O = not known, investigation impossible.

[1] http://www.buwal.ch/forst/e

Natural Hazards: Event Documentation — Basic Data — Sheet 1/4

☐ Boxes (MAXO-Code): **M** = **M**easured value; Observation **A** = **A**ssumption **X** = unclear; still to ascertain **O** = not ascertainable

Kind of process ❏ snow avalanche ❏ rockfall ❏ landslide ❏ water/debris flow

Basic information

	name	number/code	name (other municipalities concerned?)	number/code
municipality	....	☐	....	☐
waters	....	☐	....	☐
forest district	....	☐	....	☐
region	....	☐	....	☐

specific place ....

single event date ☐ ☐ ☐ ☐ time ☐ ☐ ☐ duration ☐ ☐ d ☐ h ☐ min

repeated event ❏ daily

❏ weekly from date ☐ ☐ ☐ to date ☐ ☐ ☐

❏ monthly

uppermost (highest) point of the release area: X / Y = ☐ / ☐ Z = ☐ [m a.s.l.]

coordinates of the front of runout zone: X / Y = ☐ / ☐ Z = ☐ [m a.s.l.]

X / Y = ☐ / ☐

date of survey: ☐ ☐ ☐

survey by (name, adress, phone): ....

Damage

		# persons dead	# persons injured	# persons evacuated
man/animals	persons	☐ ☐	☐ ☐	☐ ☐
	animals	☐ ☐	☐ ☐	☐ ☐
		# destroyed	**# damaged**	**financial loss [.....]**
real values	dwelling houses	☐ ☐	☐ ☐	☐ ☐
	industry, business, hotel buildings	☐ ☐	☐ ☐	☐ ☐
	farm buildings	☐ ☐	☐ ☐	☐ ☐
	public and infrastructure buildings	☐ ☐	☐ ☐	☐ ☐
	protection structures	☐ ☐	☐ ☐	☐ ☐
	other (to describe in Memo)	☐ ☐	☐ ☐	☐ ☐
		burying [m]	**cutting off [h]**	**financial loss [.....]**
communication/ infrastructure	national highways	☐ ☐	☐ ☐	☐ ☐
	main road	☐ ☐	☐ ☐	☐ ☐
	other road	☐ ☐	☐ ☐	☐ ☐
	railway	☐ ☐	☐ ☐	☐ ☐
	cableway, conveyor, pylons	☐ ☐	☐ ☐	☐ ☐
	cable	☐ ☐	☐ ☐	☐ ☐
	other (to describe in Memo)	☐ ☐	☐ ☐	☐ ☐
		affected area [a]	**damaged timber [m³]**	**financial loss [.....]**
forest/agriculture	forest	☐ ☐	☐ ☐	☐ ☐
	space usable for agriculture	☐ ☐		☐ ☐
	other (to describe in Memo)	☐ ☐	☐ ☐	☐ ☐

Natural Hazards: Event Documentation

Basic Data

Sheet 2/4

Damage (continued)

Memo (description of damage considering the following catchwords):
clearing (work, costs); removed material [m^3]
financial loss (public/private)
diversion of traffic
other
published early warnings
immediate measures
etc.

Regional planning

conflicts with present legally valid planning and hazard zones? ☐

affected zones (zones for building, camping, exploitation, hazard zones, etc.): ....

Protection structures

present in release area? ☐ no. in register of protection structures ....

present in transition zone? ☐ no. in register of protection structures ....

present in runout zone? ☐ no. in register of protection structures ....

Memo (description of suitability of protective measures):
kind and type of protective structures
state of the structures; assessment of suitability
remaining/new dangers
costs for repairing; for supplementary structures
other(s)

Documentation

name/adress of documentation office; title, code of report, illustrations, etc.

☐ note, study, expert's report, calculations ....

☐ newspapers, literature, historical sources ....

☐ photo documentation ....

☐ orthophotos, air photographs ....

☐ video, movie ....

☐ data about meteorology ....

Mapping

the process area, is it mapped? ☐

methodology	**release area**	**runout zone/deposition area**
	☐ in place	☐ in place
	☐ by air photographs, photographs	☐ by air photographs, photographs
	☐ remote mapping (from the opposite slope)	☐ remote mapping (from the opposite slope)
	☐ other, retrospective mapping respectively	☐ other, retrospective mapping respectively

Natural Hazards: Event Documentation | Snow Avalanche | Sheet 3/4

☐ Boxes (MAXO-Code): **M** = **M**easured value; Observation **A** = **A**ssumption **X** = unclear; still to ascertain **O** = not ascertainable

Kind of process ❏ flowing avalanche ❏ powder avalanche ❏ mixed avalanche

(in Switzerland: additional questionnaire D of Avalanche Research Institute filled in?)

Causes (meteorology)

thunderstorm
☐ ☐ duration [h]
☐ ☐ precipitation [mm]

long-duration rain
☐ ☐ duration [h]
☐ ☐ precipitation [mm]

☐ snow melt ☐ not ascertainable

Trigger qualification of statement about trigger ☐

❏ spontaneous ❏ blasting

❏ ski/snowboard ❏ other (to describe in Memo)

Release area

release area in forest ☐

exposition ☐ ☐

sliding surface: ❏ within the snow cover ❏ on soil surface

thickness of (slab) crown ☐ ☐ [m]

width of (slab) crown ☐ ☐ [m]

Runout zone

runout zone in forest ☐

volume of deposition ☐ ☐ [m^3]

quality of snow: ❏ dry ❏ wet

maximum depth of deposition ☐ ☐ [m]

maximum width of deposition ☐ ☐ [m]

Memo (description of event considering the following catchwords):

release area
state of the forest
damage to nature in the transition zone
information about peak-height of bouncing (dents in trees by impacts)
prehistory, supplementary information about meteorology (0°C-line, precipitation, snow melt)
comparison with former events; estimation of damage
etc.

Natural Hazards: Event Documentation — Rock Fall — Sheet 3/4

☐ Boxes (MAXO-Code): **M** = **M**easured value; Observation **A** = **A**ssumption **X** = unclear; still to ascertain **O** = not ascertainable

Kind of process
❏ rock fall single stones < 0,5 m
❏ rock fall single blocks 0,5 m – 2 m
❏ rock fall blocks, rock mass > 2 m
❏ rock fall large rock mass ("Bergsturz")
❏ ice-fall

Causes (meteorology)

thunderstorm
☐ ☐ duration [h]
☐ ☐ precipitation [mm]

long-duration rain
☐ ☐ duration [h]
☐ ☐ precipitation [mm]

☐ snow melt ☐ not ascertainable

Trigger qualification of statement about trigger ☐

naturally by:
❏ general
❏ landslide / erosion
❏ earthquake
❏ man-induced (to describe in Memo)
❏ other (to describe in Memo)

Release area

break out from ☐
❏ rock cliff
❏ talus slope
❏ glacier

number of blocks ☐ ☐

released volume ☐ ☐ [m³]

Transition zone

soil:	**talus slope**	**forest**	**pasture, meadow**
length of sector:	☐ ☐ [m]	☐ ☐ [m]	☐ ☐ [m]

Deposition area

total volume ☐ ☐ [m³]

stones, blocks, large blocks ☐ ❏ 1 ❏ 2 – 10 ❏ 11 – 50 ❏ > 50

volume of the largest block ☐ ☐ [m³]

Memo (description of event considering the following catchwords):
release area
state of the forest
damage to nature in the transition zone
information about peak-height of bouncing (dents in trees by impacts)
prehistory; supplementary information about meteorology (0°C-line, precipitation, snow melt)
comparison with former events; estimation of damage;
etc.

Natural Hazards: Event Documentation | Water/Debris Flow | Sheet 3/4

☐ Boxes (MAXO-Code): **M**=**M**easured value; Observation **A**=**A**ssumption **X**=unclear; still to ascertain **O**=not ascertainable

Kind of process ❏ flood / inundation ❏ debris flow (in channel)
(data passed on the appropriate hydrological survey office?)

Other processes involved (minor importance):

❏ flood ❏ debris flow (in channel) ❏ bank erosion
❏ fluvial sedimentation ❏ landslide ❏ rock fall
❏ other (to describe in Memo)

Causes (meteorology)

thunderstorm	long-duration rain	☐ snow melt	☐ not ascertainable
☐ ☐ duration [h]	☐ ☐ duration [h]		
☐ ☐ precipitation [mm]	☐ ☐ precipitation [mm]		

Trigger qualification of statement about trigger ☐

❏ clogging by wood debris ❏ overflow because of too small cross-section
❏ clogging by bedload ❏ dike failure/levee failure
❏ clogging at bridge/culvert ❏ overloading of sewerage system
❏ other bottleneck ❏ other

Assessment of processes in the channel

	major	medium	minor		major	medium	minor
lateral erosion (bank, embankment)	❏	❏	❏	debris flow deposit in the channel	❏	❏	❏
vertical erosion	❏	❏	❏	deposit of wood debris in channel	❏	❏	❏
bed aggradation	❏	❏	❏				

Flood / deposition area

volume of deposed solids	☐ ☐ [m³]	medium thickness of deposits	☐ ☐ [m]
volume of debris flow deposit	☐ ☐ [m³]	medium flood depth	☐ ☐ [m]
volume of deposed wood debris	☐ ☐ [m³]	max. depth of debris flow deposit (head)	☐ ☐ [m]
maximum discharge	☐ ☐ [m³/s]		

(please map the hydrometric station on form-sheet 4/4)

Memo (description of event considering the following catchwords):
Q_{max} hydrometric station
general mechanism of process, calculation and estimation methods
state/assessment of existing sediment retention basins
prehistory (wet, medium, dry; frost)/supplementary information about meteorology (altitude of 0°-line, hail, etc.)
flood marks (where?; depth)
comparison with former events; estimation of damage
etc.

Natural Hazards: Event Documentation | Landslide | Sheet 3/4

☐ Boxes (MAXO-Code): **M** = **M**easured value; Observation **A** = **A**ssumption **X** = unclear; still to ascertain **O** = not ascertainable

Kind of process ❑ landslide ❑ debris slide/flow at slope ❑ sink, collapse

Other processes involved (minor importance)

☐ flood ☐ debris flow (in channel) ☐ bank erosion
☐ fluvial sedimentation ☐ landslide ☐ rock fall
☐ other (to describe in Memo)

Causes (meteorology)

thunderstorm
☐ ☐ duration [h]
☐ ☐ precipitation [mm]

long-duration rain
☐ ☐ duration [h]
☐ ☐ precipitation [mm]

☐ snow melt ☐ not ascertainable

Trigger qualification of statement about trigger ☐

❑ natural ❑ man-induced
❑ by fluvial erosion ❑ other (to describe in Memo)

Main scarp area

depth of rupture surface (scarp area) ☐ ☐ [m]
width of rupture surface ☐ ☐ [m]
depth of sink ☐ ☐ [m]
area of scarp/ area of sink ☐ ☐ [m²]
body of landslide/ sunken mass ☐ ❑ bedrock ❑ soil
rupture surface/ sunken mass ☐ ❑ on bedrock ❑ in soil

Main body and foot area

depth of foot ☐ ☐ [m]
moved mass ☐ ☐ [m³]

depth of rupture surface (body): ☐
❑ 0–2 m shallow
❑ 2–10 m medium
❑ >10 m deep-seated

transition to debris flow (at slope) ☐
deposition in a river channel ☐ ☐
if yes: backing up of waters ? ☐

velocity: ☐
❑ active >10 cm/y
❑ slow 2–10 cm/y
❑ substable <2 cm/y (very slow)

Memo (description of event considering the following catchwords):
springs
general mechanism of process
hydrology of the relevant catchment
prehistory (wet, medium, dry; frost)
supplementary information about meteorology (altitude of 0°, precipitation, snow melt, etc.)
comparison with former events
etc.

Natural Hazards: Event Documentation | **Mapping** | **Sheet 4/4**

Event municipality .... process .... digitalized? ☐

Mapping scale 1 : .... date ☐ ☐ ☐

name, adress, phone ....

5.3 Features and Fingerprints

The people on site are working as a kind of detectives. They find the body, but they don't see the murderer. So they rely on clues, more or less reliable witnesses and their own perception. It's always a kind of a puzzle to put all the different bits of information together for a general picture, that fits in the end. So:

- Take care with conclusions.
- Always be aware of the fact, that your conclusions are an interpretation of what you see afterwards.
- Always try to find two or more independent features which might proof your conclusions.

First collect all information you can get (observers, silent witnesses, gauging stations ans.). Then you may start to think about the plausibility and a reasonable idea about what was going on (reason, process, immediate and following measures).

5.3.1 Flooding and Sediment Transport Processes (by J. Hübl)

Floodings occur by overtopping the channel's banks and overflowing the valley area. Triggering precipitations are on the one hand short convective rainfalls with high intensity, on the other hand rainfalls with long duration and lower intensities. The form of the discharge hydrograph is related to the rainfall distribution, to the shape of the basin area, to the type of soil and the land-use forms.

Main features for floods are lines defined by high water marks. Beside process – related – features the contact with eyewitnesses (abutting owners, fire brigade etc.) may give useful information about the event (e.g. time distribution, photographs).

Floodings are in a way always connected with sediment transport. Flood sediments occur in numerous settings, such as fans, splays, channel fills, overbank deposits and backwater sights (WILLIAMS and COSTA, 1988). The form of the transported and deposed sediments is conditioned by the discharge and the geological disposition of the basin area. Main features are the sediment setting and the areas of deposition.

References

WILLIAMS, G., COSTA, J. E. (1988): Geomorphic Measurements after a Flood. In: Flood Geomorphology, edited by V.R. BAKER, R.C. KOCHEL, P.C. PATTON. John Wiley&Sons, New York, pp. 65-77

Precipitation	Features (examples)	Information and possible interpretation
 Deposits of hailstones (Obersaxen, Switzerland) Kienholz, 1992	Private gauging stations of e.g. farmers Form of precipitation (e.g. hail) Flooded depressions	❑ **Estimation of the precipitation height** ❑ **Calibration of hydrological models** ❑ **Intensity and rainfall distribution**

Flooding	Features (examples)	Information and possible interpretation
 Muddy signs at trees, deposed fine-grained fluvial sediments, leafs and branches (Fischbach, Austria) Hübl, 2002	Stage lines defined by: • depressed grass • accumulated leafs, branches, rubbish etc. • muddy signs on trees, buildings, etc. • log jams	❑ **Flow depth and channel geometry** ❑ **Estimation of mean velocity** ❑ **Estimation of peak discharge** ❑ **Calibration of simulation models** ❑ **Hazard zone mapping**

Sediment transport	Features (examples)	Information and possible interpretation
 Fluvial sediments (Gertnertalbach, Austria) Hübl, 1999 Accumulated branches (Hassbach, Austria) Steinwendtner, 1999 	Deposition of transported sediments: • deposition areas (ripples, dunes, antidunes,ribs, bars) • grain size • erosion areas • deposed material from different geological zones • shape and roundness of the sediments • sorted sediments • impact signs on buildings, trees, etc. • interaction with control structures	❑ **Process type** ❑ **Grain size distribution** ❑ **max grain size** ❑ **Volume of transported sediments** ❑ **Height of deposition** ❑ **Spatial distribution of deposits** ❑ **Source of the deposed sediments** ❑ **Input parameters for simulation software** ❑ **Hazard zone mapping** ❑ **Effectiveness of control structures**

5.3.2 Debris Flow and Mud Flow (by J. Hübl)

According to HUNGR et al. (2001) a debris flow is a very rapid to extremely rapid flow of saturated non-plastic debris in a steep channel. It may occur in a series of surges, ranging in number from one to several hundred and separated by flood-like intersurge flow. The key characteristic of a debris flow is the presence of an established channel or regular confined path, that controls the direction of the flow and in which the debris flow is a recurrent process.

During the ongoing process a kind of longitudinal sorting occurs, leading to a typical bouldery front, a more homogenous suspension as body and to a turbulent or hyperconcentrated flow as tail of the debris flow. In the deposition area (normally at the fan) the debris flow front stops at first, the body bypasses and reaches lower fan areas, creating typical steep fronted lobes without segregation. The distal fan areas can normally be reached only by the tail of the debris flow or subsequent flood runoff, possibly reworking the deposits.

As reported by many authors (e.g. STINY, 1910; JOHNSON, 1970; AULITZKY, 1980, WILLIAMS and COSTA, 1988), U-shaped channel cross sections, marginal levees of coarse boulders and steep-fronted lobate deposits are diagnostic features of debris flows.

Mud flows are according to HUNGR et al. (2001) very rapid to extremely rapid flows of saturated plastic debris in a channel, involving significantly greater water content relative to the source material. They share many morphological and behavioural aspects with debris flows, but the clay fraction modifies the rheological properties.

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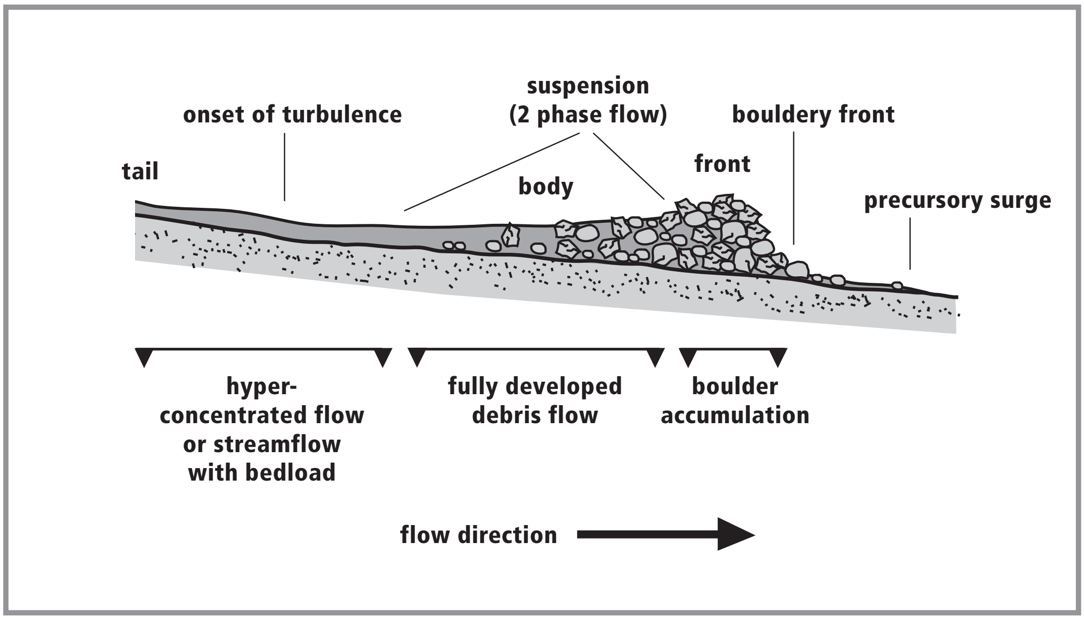
Fig. 6 Sketch of a debris flow surge based on PIERCON T.C. (1986).



Transit zone


U-shaped channel cross-section (Ritigraben, Switzerland) Kienholz, 1994


Lateral levees of coarse clasts (Ergisch, Switzerland) Kienholz, 1992

Features (examples)

Debris flow marks as "impact line"

polished surface on bedrock (continuous)

signs (mud silting) on trees, surface, buildings, etc.

U-shaped channel cross section

Superelevation in bends

Lateral levees of coarse clasts, the biggest ones resting on the top (upward coarsening)

Big boulders at the margin of the flow

Interactions with control structures

Impact signs due to boulders or large gravels on trees, buildings, etc.

Information and possible interpretation

- ❑ **Flow type (mud or debris flow)**
- ❑ **Channel geometry and flow depth**
- ❑ **Velocity estimation**
- ❑ **Discharge estimation**
- ❑ **Grain size distribution**
- ❑ **Impact force estimation**
- ❑ **Effectiveness of control structures**
- ❑ **Interpretation used for a calibration of simulation models**

Deposition zone


Front deposit with sharp margin (Wassertalbach, Austria) Hübl, 1998

Pressure ridges (Kohnerbach, Austria) Hübl, 1994

Features (examples)

Debris flow front deposit: deposition of large boulders without more or less any fine material (matrix) with a steep front

Debris flow body deposit
- lobate deposits with a sharp and well defined margin between debris deposits and undisturbed ground cover (e.g. grass)
- poorly sorted gravel, upward coarsening
- interstices of the deposits filled with a matrix of clay, silt, sand and fine gravel (matrix)

Pressure ridges

Signs (mud silting) on trees, buildings, etc.

Impact signs due to boulders or large gravels (on trees, buildings, etc.)

Debris flow tail deposits: deposits of sand, silt and clay overlaying ground surface and coarse deposits

Information and possible interpretation

- ❑ **Delineation of deposition areas**
- ❑ **Number of surges**
- ❑ **Run-out distance**
- ❑ **Spatial distribution of deposit heights**
- ❑ **Width and depth of deposed lobes**
- ❑ **Volume of debris flow**
- ❑ **Spatial distribution of grain size**
- ❑ **Maximum grain size**
- ❑ **Shear strength**
- ❑ **Recalculation of impact forces**
- ❑ **Frequency (analysis of historic events)**
- ❑ **Hazard zone mapping**
- ❑ **Evaluation of simulation software**

5.3.3 Rock Fall (by J. Hübl)

Rock fall consists of free falling blocks of different sizes that are detached from a cliff or a steep rock wall. But „rock fall" is a generic term under which we can find different phenomena and an international definition for rock fall is still missing. So we have to distinguish between the fall of individualised elements and a collapsing in mass. The different kinds of rock falls are classified in function of volume of mass in movement and the mechanism of propagation (HOESLE, 2001).

Especially in German different definitions for the term rock fall are existing. They are mainly depending on the volume of the transported material. German terms for a distinction of the different processes are given by POISEL (1997):[1]

Steinschlag	**0,01 m³** (is equivalent to approximately 20 cm block size)
Rock fall	**0,1m³** (is equivalent to approximately 50 cm block size)
Blocksturz	**2 m³** (is equivalent to approximately 150 cm block size)
Felssturz	**10 000 m³** (is equivalent to approximately 25 m block size)
Bergsturz	**> 10 000 m³**

The specified volumes are equivalent to the size of the impact block or the over-all volume.

[1] Some different classifications are also used (see p.18)

Following WHALLEY (1984, in SELBY, 1993) the term "rock fall" is commonly used to refer to a collection of processes which may involve the removal of material ranging in size from large rock masses through single joint blocks to particles ranging from boulder-size to gravel-size. So SELBY (1993) makes distinctions between:

- Rock-mass falls
- Rock slab and block falls
- Rock particle falls

Following the characterisation of VARNES (1978) rock fall is a process in which the vertical component is predominant, the moisture content low and the rate of movement extremely rapid.

Usually there are distinct features in the release area, in the transit and deposition zone. Only eye-wittnesses can give an information about time activity as well as the kind of process.

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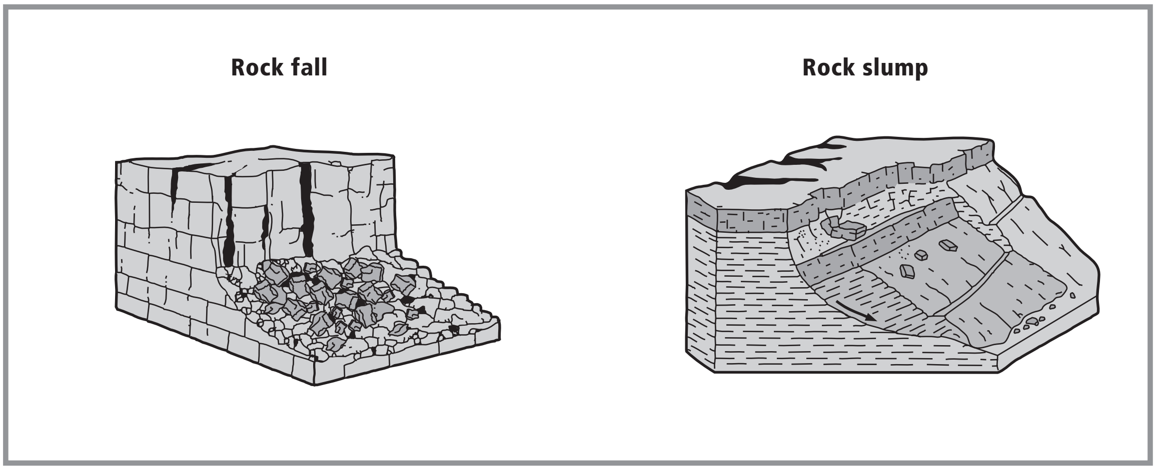
Fig. 7 Primary mechanisms for rock fall based on VARNES (1978).



Release area	Features (examples)	Information and possible interpretation
 Rockfall release (Sundlauenen, Switzerland) Kienholz, 2002	Geological structure; geomorphological situation (cliff, boulder, profounded or shallow material)	❑ **Location**
		❑ **Dimension and geometry (length, width, depth) of failure**
	Topographical situation (altitude, exposition, slope)	❑ **Cause of failure; failure mechanism (e.g. free fall, sliding,toppling)**
	Discontinuity (fissures, crack-system)	❑ **Frequency (high/moderate/less)**
	Detachment zones	❑ **Size of detachable stones**
	Weathering (rock colour)	❑ **Stabilisation/destabilisation of source area caused by the root system**
	Vegetation cover (stabilisation/destabilisation)	❑ **Water influence**
		❑ **Fracture tendency during failure process**
	Hydrogeological situation (springs or water drop-outs)	❑ **Initial failure depth**

Transit zone	Features (examples)	Information and possible interpretation
 Rockfall impact on a tree (Sundlauenen, Switzerland) Kienholz, 2002	Impact signs on trees (height/size of impact)	❑ **Jumping-height and length**
		❑ **Trajectories**
	Impact signs on ground (distance/depth of funnels)	❑ **Frequency**
	Topography of rockfall-path (inclination, soil properties, roughness, exposition)	❑ **Impact load**
		❑ **Energy dissipation (vegetation)**
	Cross section morphology	❑ **Fracturing during impact**
	Vegetation cover	❑ **Concentration of rockfall influenced areas**
	Deposed rocks	❑ **Evaluation of simulation programs**

Deposition zone	Features (examples)	Information and possible interpretation
 Rockfall deposition (Stubachtal, Austria) Hübl, 1996	Topography of surface (e.g. scree slope)	❑ **Deposed volume**
		❑ **Grain size (max.)**
	Slope inclination	❑ **Run out slope**
	Position of deposits	❑ **Run out distance (spatial extend)**
	Size of deposed rocks	❑ **Rockfall influenced area**
	Shape of deposed rocks	❑ **Possible causes of deposition**
	Obstacles	❑ **Fracture mechanism of fallen rocks**
		❑ **Evaluation of simulation programs**
		❑ **Hazard mapping**

5.3.4 Landslides (by J. Corominas)

Under the heading of landslides have been included here both rotational and translational slides, earthflows (CRUDEN & VARNES, 1996) and mudslides (HUTCHINSON, 1988). Landslides range from few cubic meters to thousands of millions of cubic meters.

The main common features of these movements consists on the rapid to slow downslope displacement of soil and rock which takes place mainly on one or more, discrete bounding slip surfaces. In rotational and translational slides the slipping mass moves as an essentially coherent unit. Earthflows and mudslides show a lobate or elongate shape. Even though they are considered as flows, they slide rather than flow.

Many of these movements experience periodical reactivations, mostly related to the rainfall episodes. The appropriate understanding of the driving mechanism and the effective design of remedial measures require the precise description of the movement and of its relevant features, which are specific of each landslide type.

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Scarp area

Main scarp (Los Olivares, Spain) Corominas, 1986

Water seeps and springs (Cava, Spain) Corominas, 1987

Features (examples)	Information and possible interpretation
Main scarp retrogressive failure	❑ **Head of the landslide is progressing backwards by retrogressive failures. The landslide has instabilized the upper slope**
	❑ **Height of the scarp**
	❑ **Estimation of the depth of the surface of failure**
Features indicating previous movements (i.e. soil structure, tilting)	❑ **Datable material for determination of the landslide age**
Water seeps and springs	❑ **Information about the aquifer**
	❑ **Distribution of macropores and groundwater paths**
Striations	❑ **Evidence of shearing**
	❑ **Direction/vector of displacement**

Landslide body

Graben/twin ridges (Grindelwald, Switzerland) Kienholz, 1973

Lateral ridge (Vallcebre, Spain) Corominas, 1982

Features (examples)	Information and possible interpretation
Graben	❑ **Degree of circularity of the failure**
	❑ **Estimation of depth of the surface of rupture**
Longitudinal shear	❑ **Lateral shear surface**
	❑ **Boundary of the landslide or local failure**
Tension cracks (arranged parallel to the direction of movement)	❑ **Development of lateral shear surfaces**
	❑ **Boundary of the landslide**
Lateral ridge	❑ **Indication of ground erosion and lateral shear surfaces (Corominas, 1995)**

Landslide body (cont.)	Features (examples)	Information and possible interpretation
 Transverse tension cracks (Pont de Bar, Spain) Corominas, 1982	Transverse tension cracks Displaced wall	❏ **Landslide stretching** ❏ **Development of a graben or local failure** ❏ **For translational movements it will enable the estimation of the depth of the slip using balanced cross section methods (Bishop, 1999)**
 Offset features and pressure ridges (Falli Hölli, Switzerland) Kienholz, 1994	Offset feature Pressure ridges Mud intrusion Upright standing trees	❏ **Longitudinal displacement** ❏ **Presence of compression zones** ❏ **Presence of compression zone and fluidised mud** ❏ **Presence of rigid block** ❏ **In flow-like movements indicates sliding rather than flowing mechanisms or the presence of a plug**
 Displaced road (Murrazzano, Italy) Kienholz, 1995	Outcrop of the shear surface Displaced objects	❏ **Sampling for shear strength parameters** ❏ **Landslide thickness** ❏ **Nature of failure surface** ❏ **Absolute displacements** ❏ **Displacement vectors**
 Bended and tilted trees/slumgullion landslide (Colorado, USA) Kienholz, 1995	Bended or tilted trees	❏ **Rotated blocks** ❏ **Flow-like movements**

Petteneu (Tyrol, Austria), Kreuzer, 1999

5.3.5 Avalanches (by J. Hübl)

Avalanches are falling masses of snow that can contain rocks, soil, wood or ice. Avalanches fall when the weight of accumulated snow on slope exceeds the forces within the snowpack or between the snowpack and the ground which holds the snow in place. The balance between theses forces can be changed by further snowfall, by internal changes in the snow cover, or by the weight of a single skier. The often small force required to start the snow sliding is called an avalanche trigger.

As reported by some authors (e.g. McCLUNG 1993, DAFFERN 1992, LACKINGER 2000) there are two general types of snow avalanches:

- **Loose snow avalanches** which originate in cohesionless snow and which start from one point, gathering more and more snow as they descend. They move down the slope in a typical triangular pattern as more snow is pushed down the slope and entrained into the slide.
- The second type, the **slab avalanches,** is usually more dangerous.

It initiates by a failure at depth in the snow cover, ultimately resulting in a block of snow, usually approximating a rectangular shape, that is entirely cut out by propagating fractures in the snow.

So it will start when a large area of cohesive snow begins to slide at the same time.

Both types occur in wet and dry snow, either sliding down on a layer of snow within the snowpack or along the ground surface. Large avalanches can attain sufficient speed for some of the snow to be airborne.

The entire movement procedure is called avalanche, beginning from the starting zone, the avalanche track till the run out, debris or deposit zone.

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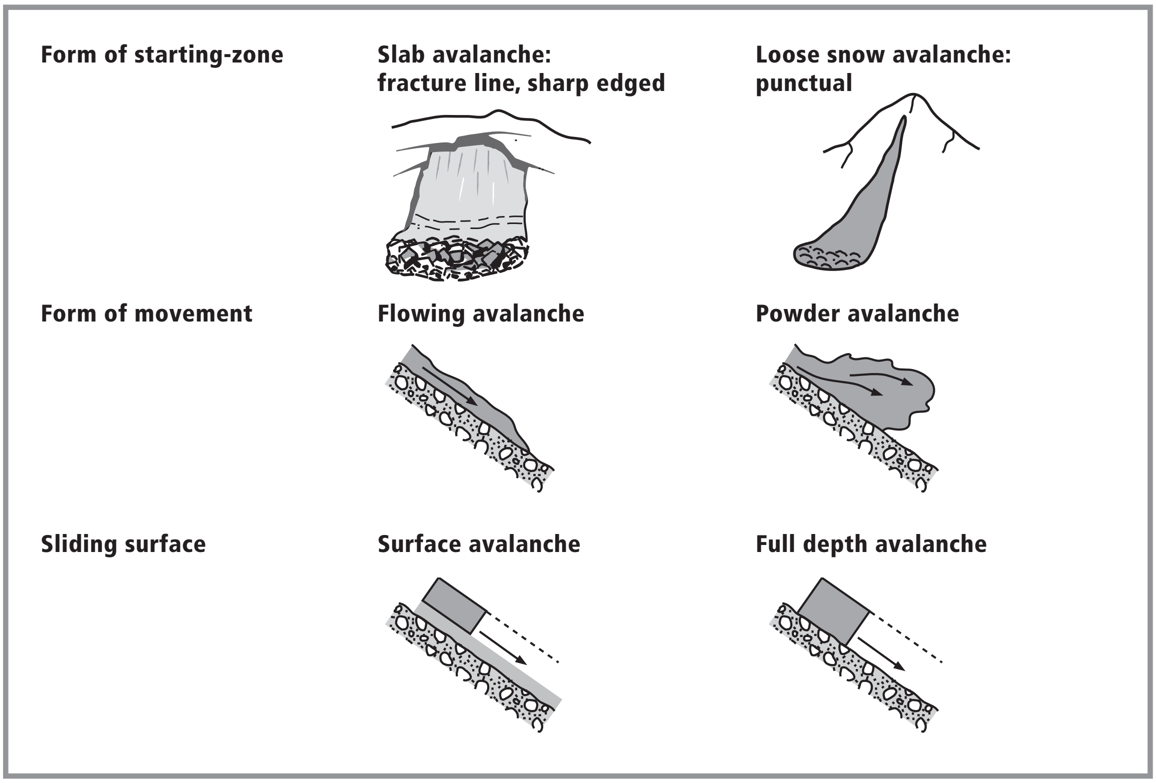
Fig. 8 Classification of avalanches based on MUNTER W. (1991).



Starting zone	Features (examples)	Information and possible interpretation
 Crown of a slab avalanche (Gschnitztal, Austria) Kreuzer, 2001	Visible tracks (human, animals) vs. no tracks	❏ **Artificial triggering or natural release**
	Crown: breakaway wall on top of the slab, sharp edged fracture line Bed surface: surface over which avalanche slides Flanks: lateral boundary of the slab	❏ **Slab avalanche: large area of cohesive snow slid simultaneously initiated by failure at depth in the snow cover, downslope component of the weight approached shear strength in weak layer and sufficient rate of deformation enabled fracture propagation**
	Snow profile observation of the crown: • snow layers • snow height • density of snow layers • hardness • grain shape • snow temperature	❏ **Knowledge of release height and area allows estimation of release volume, average snow density times the release volume gives the avalanche release mass**
	Crown reaches to the ground surface (visible soil); release height equals snow height, grassy or rocky ground	❏ **Full-depth avalanche. Possible triggering: snow gliding favoured by low ground roughness and/or high water content**
	Stauchwall covered with big tables	❏ **Hard slab avalanche**
	No big tables at Stauchwall	❏ **Soft slab avalanche**
Combination of avalanche types: slab avalanche triggered by a loose snow avalanche (Flüela, Switzerland) Kienholz, 1994 	No definite fracture lines Layer on which the snow slides is not identifiable Triangular pattern	❏ **Loose snow avalanche start at one point on the snow cover and grow in size as they descend. Snow with very little internal cohesion triggered by surface melting or by external forces such as sluffs falling from the rocks or trees**

Track	Features (examples)	Information and possible interpretation
 Avalance path (Valzur, Austria) Kreuzer, 1999	Spots without snow, visible soil, broken trees	❏ **Identification of avalanche path**
	Superelevation in outer bends	❏ **High velocity; high centrifugal forces**
 Avalanche track. The flow component followed the channel; the powder component crossed the ridge and destroyed (right part of photograph) a part of the forest (Valzur, Austria) Kreuzer, 1999	Part of path which corresponds to terrain	❏ **Track of the flow component**
	Path which does not follow the terrain	❏ **Path of powder component**
	Broken or uprooted trees	❏ **Indicator of impact forces**
	Position of trees	❏ **Direction of motion**

Run out zone	Features (examples)	Information and possible interpretation
 Snow avalanche deposition (Lötschental, Switzerland) Kienholz, 1984	Area with disturbed, sometimes dirty snow	❏ **Deposition area of the snow cover**
	Depth down to undisturbed snow	❏ **Deposition height**
	Point of furthest reach of the debris	❏ **Run out distance**
	Fine debris	❏ **Dry dense flow avalanche**
	The avalanche creates grooves or scores the surface while passing the lower portion of the track or runout zone.	❏ **Wet snow avalanche (typical avalanche in spring time with melting heavy snow forming round boulders – hard like concrete)**
	Debris looks like fingers or arms	
 Avalanche deposition with Stauchwall (Gschnitztal, Austria) Kreuzer, 2001	Hard and dense debris including snow boulders up to 0,5 m in diameter	❏ **Debris of a wet snow avalanche**
	Grooves, fingers	❏ **Airborne component of a highspeed avalanche**
	Fine material, dust (avalanche did not follow the terrain; snow marks on houses)	❏ **Powder avalanche (Snow marks caused by powder component)**
Destroyed house by snow avalanche (Krössbach, Austria) Hübl, 2001 	Damages to buildings or other structures like skilift, power poles, cars, trees, etc.	❏ **The type of damages allows to recalculate the lower limit of impact forces**
		❏ **Please notice every damage like (e.g.):** • damaged windows (what kind of windows) • damaged doors (steel or wood) • damaged truss, roof or chimney (what kind of construction) • damaged walls (bricks or concrete walls)
		❏ **Impact pressure (kPa):** • Break windows = 1 kPa • Push in doors = 5 kPa • Destroy wood-frame structures = 30 kPa • Uproot mature spruce = 100 kPa • Move reinforced-concrete structures = 1000 kPa

Wolfgrubenlawine (Austria) Kreuzer, 1988