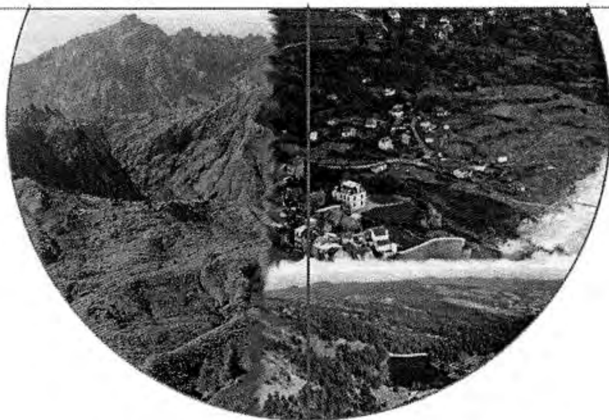
Symposium

'Geomorphology : from expert opinion to modelling'



A tribute to Professor
Jean-Claude Flageollet

Proceedings of the Symposium held in Strasbourg, France, on April 26-27, 2002.

Edited by D. Delahaye, F. Levoy and O. Maquaire

Geomorphological study of a channelized debris-flow in the Faucon watershed (Alpes-de-Haute-Provence, France)

A. Remaître, O. Maquaire

Institut de Physique du Globe de Strasbourg, IPGS-EOST, UMR 7516 CNRS-ULP, 5 rue Descartes, 67084 Strasbourg Cedex

Résumé : *La compréhension et la gestion des risques induits par les laves torrentielles nécessitent une approche pluridisciplinaire regroupant les compétences de l'ingénierie géotechnique, de l'hydraulique, de la climatologie, de la géologie, de la rhéologie, de l'hydraulique et de la géomorphologie. Cette dernière apporte des informations indispensables à la recherche des zones sources des laves torrentielles. Une étude géomorphologique a été menée sur le torrent de Faucon (bassin de Barcelonnette, Alpes-de-Haute-Provence), où une importante lave torrentielle s'est produite le 19 août 1996. Cette lave s'est formée à la suite d'un violent orage sur les hauteur du bassin de réception, provoquant la rupture brutale d'un embâcle naturel (volume de plusieurs centaines de m^3) dans le chenal vers 2200 m d'altitude. Le volume total de la lave approche les 100 000 m^3. Les analyses granulométriques des dépôts de la lave torrentielle permettent de décrire un écoulement d'abord granulaire dans les premiers hectomètres puis cohésif jusqu'à la zone principale de dépôt, qui traduit l'hétérogénéité géologique observée dans le bassin versant du Faucon. L'analyse morphologique associée aux analyses comparatives des dépôts de laves et des formations superficielles (granulométrie et pétrographie) en laboratoire ont permis de montrer que des formations superficielles (marnes noires altérées et moraines essentiellement) ont été incorporées à la lave pendant sa propagation. La lave a donc été granulaire dans les premiers hectomètres puis serait devenue cohésive jusqu'à la zone de confluence avec l'Ubaye. Les matériaux libérés par les zones de contribution proviennent de l'érosion des berges et du lit du torrent (sapement, reprise des dépôts dans le chenal) et des mouvements de terrain affectant les versants contigus au chenal (ravinements, glissements superficiels, éboulements, etc.). Ces résultats permettent de distinguer deux zones sources bien distinctes : une zone de déclenchement stricto sensu et plusieurs zones de contribution.*

Mots clés : *laves torrentielles, écoulement granulaire, écoulement cohésif, zones sources.*

1. Introduction

Channelized debris-flow in mountainous areas are able to transport large quantities of sediment downslope, producing complex distributions of deposits and eroded surfaces along their flow paths. Knowledge of the risk induced by channelized debris-flow requires a multidisciplinary approach regrouping such disciplines as geotechnical engineering, hydrology, climatology, rheology, hydraulic, geology and geomorphology. Geomorphology is particulary useful in the investigation of the flow triggering areas [1,2,3], this paper is the result arising from two years of geomorphological research since 1998 in the Faucon watershed, where a large channelized debris-flow occured on August 19th 1996. Grain-size distribution and petrographic analysis of 1996 flow deposit and quaternary deposits show the existence of different source areas.

2. Study area

The faucon catchment (10,5 km^2 in area, 7 km in length) is located on the south-facing slope of the Barcelonnette basin. The watershed crest is capped by a sheet thrust (flyschs and limestones) and its lower slopes are underlain by less resistant callovo-oxfordian black marls [Fig.1]. Under 2200 m, slopes are covered by surficial deposits like screes (in the upper part of the watershed), moraines or slope deposits. The stream and the slopes area affected by several mass movements (gullying, landslides, etc.). The faucon stream has been very active since the middle of the 19th century. The increase in torrential activity is to be explained by the conjunction of several favourable factors including lithology, tectonics, climate and the evolving landuse [4].

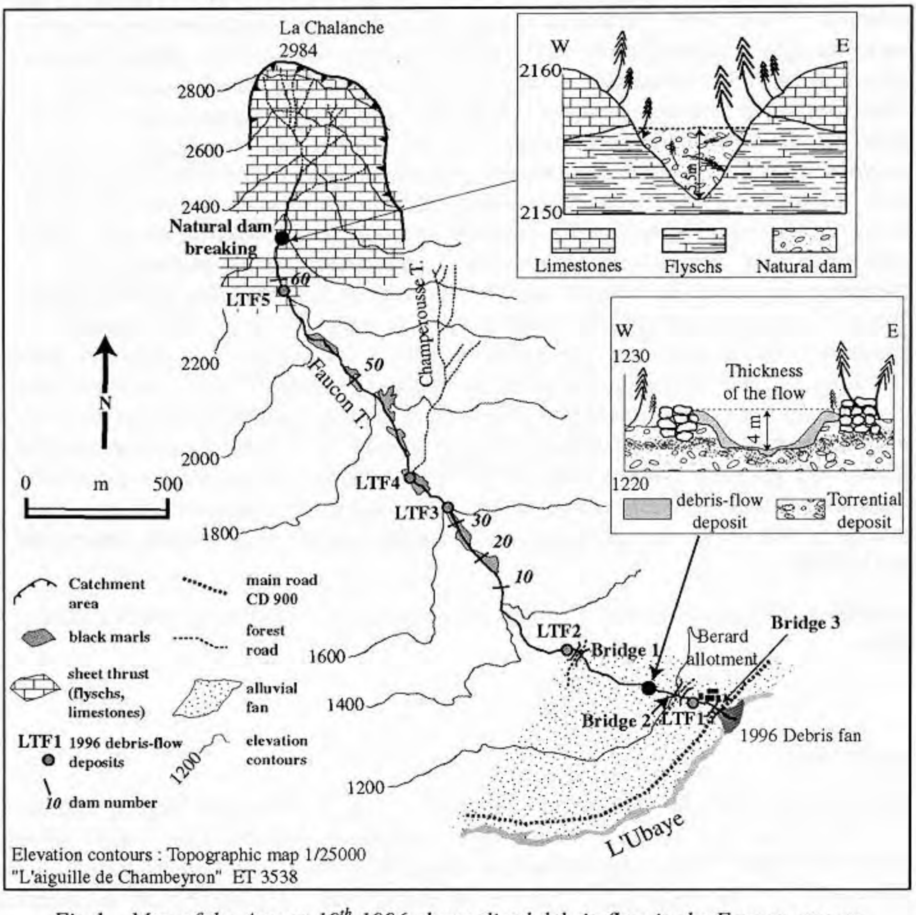


Fig 1 – Map of the August 19th 1996 channelized debris-flow in the Faucon stream

3. The August 19th 1996 channelized debris-flow

The August 19th 1996 channelized debris-flow was initiated at 14.15 GMT after a severe thunderstorm over the catchment basin and the rupturing of a natural dam (2150 m) in the torrential stream caused the debris-flow [Fig.1]. At 14.30 GMT, the flow reached an allotment located on the alluvial fan, a few meters near the torrential stream. Velocities were back-calculated using the forced vortex equation [5] and multiplied by the cross-sectionnal area to obtain peak discharge estimates, which ranged from 95 to 105 m^3/s. Approximately 100,000 m^3 of sediment was deposited during this event [6].

4. The laboratory tests

Five deposits of the flow (LTF1 to LTF5) and several superficial deposits (screes, moraines, weathered black marls) were sampled for the purpose of comparison. Grain-size distribution and petrographic analysis were carried out for all samples. The silt fraction (<50 mm) was found to increase from the upper part (LTF5) to the lower part (LTF1). The flow was therefore initially granular (LTF5), then cohesive (LTF4-LTF1) [Fig.2A]. This type of channelized debris-flow is common in heterogeneous bedrock. The petrographic analysis shows the upper deposit (LTF5) as being poor in marl. The black marl part increases in the other deposits (LTF4-LTF1), while the flysch fraction decreases [Table 1].

	Petrographic constitution (in % of the fraction < 100 mm)				
	Black marls	Flyschs	Limestones	Sandy limestones	Bubbled limestones
Screes	0-2	53-87	2-19	1-17	0-10
Weathered Black marls	68-86	0-8	2-27	0-3	0-2
Morainic deposit	14-30	7-31	25-41	8-39	3-8
LTF1	46	36	8	8	2
LTF2	44	37	8	9	2
LTF3	41	38	9	9	3
LTF4	34	41	10	11	4
LTF5	4	61	12	16	7

Tab.1 – Petrographic analysis of the 1996 channelized debris-flow and of surficial deposit samples

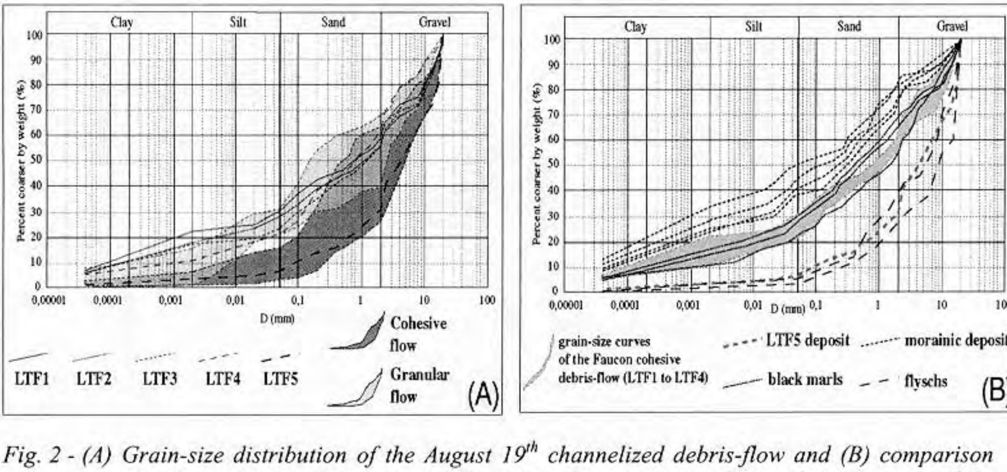


Fig. 2 - (A) Grain-size distribution of the August 19th channelized debris-flow and (B) comparison between the grain-size distribution of the debris-flow and several superficial deposits of the Faucon catchment.

The grain-size distribution of quaternary deposits shows that grain-size characteristics of weatherd black marls are very close to those of the cohesive debris-flow deposits. Grain-size characteristics of the upper debris-flow deposit (LTF5) and the scree deposits are similar [Fig.2B].

5. Conclusion

The 1996 channelized debris-flow was probably triggered after the (re)mobilisation of scree deposits (flyschs, limestones). The passage of the flow through the black marl outcrops increased scouring and erosion (bulking process). Channel scour is responsible for the difference in sediment accumulation between the breached dam (1000 m^3 at most) and the depositional area (100,000 m^3) but cannot be determined directly because no information is available on the channel fill before the event. The debris flow initiation process seems to be controlled by two different areas : the triggering or initiation area, and several contributing (scouring/erosion) areas.

References

[1] Costa, J.E. Physical geomorphology of debris-flow. *In* J.E. Costa and P.J. Fleisher (eds.) *Developments and Applications of Geomorphology*, 268-317(1984).

[2] Wieczorek, G.F., Mandrone, G., DeCola, L. Influence of hillslope shape on debris-flow initiation. *In* Proc of *1st International Conference on Debris-flow Hazard Mitigation : Mechanics, Prediction and Assessment*. San Francisco, 21-31(1997).

[3] Cojean, R., Bonnet-Staub, I. Mécanismes d'initiation des laves torrentielles dans les Alpes françaises. *In* Proc of *8th International Congress International Association for Engineering Geology and the Environment*. Balkema Rotterdam, 2075-2082(1998).

[4] Flageollet, J.C., Maquaire, O., Martin B., Weber D. Landslides and climatic conditions in the Barcelonnette and the Vars basins (southern french Alps, France). *Geomorphology* 30, 65-78(1999).

[5] Johnson, K.A., Rodine, J.R. Debris-flow. *In* Brundsen, D., Prior D.B. (Eds.) *Slope instability, John Wiley and sons*. Chichester, 257-361(1984).

[6] Remaître, A., Maquaire, O., Pierre, S. Analyse d'une lave torrentielle dans le torrent de Faucon. Géomorphologie, *in press*.