Investigating rockfall failure configurations using terrestrial laser scanner (TLS)

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Outline

- Introduction
- The Mont Saint Eynard (French Alps)
- Structural analysis by laser scanner
- Failure configurations and mechanisms
- Conclusion
Different processes can lead to a rockfall
   => influence of meteorological factors.

First step is, using TLS data, to know the influence of the rock mass structure on the prone-to-fail compartments:

   => structural analysis at different scales
   => links with failure configurations, shape of fallen compartments, failure mechanisms
The Mont Saint Eynard

Shaded: sedimentary massifs
Cross pattern: external crystalline massifs
BMF: Belledonne Middle Fault
(after Frayssines, 2006)

A: Sappey syncline
B: Ecoutoux anticline
Continuous and dashed red lines: faults
Blue squares: TLS investigated zones
The Mont Saint Eynard

- Upper cliff (Tithonian) ~120m
- Forested slope (Kimmeridgian) ~100m
- Lower cliff (Sequanian) ~240m
Laser scanning of the cliff

TLS Scan 2009 to 2013

750m

~7000m

TLS Scan 2013

300m

ALS Scan 2011
Structural analysis from TLS data
Structural analysis from TLS and field data
Structural analysis from ALS data

Structural field measurements and structural analysis from TLS data
Rockfalls detection

162 studied events

Volume range: 0.01m$^3$ to 100m$^3$

75% of the rockfall volumes smaller than 1m$^3$

See Guerin et al, 2014 (NHESS D)
Fallen compartments dimensions

![Graphs showing the relationship between height, depth, and width of fallen compartments with a linear regression line and equation: \(y = 0.50x + 0.51\) with \(R^2 = 0.47\).]
Fallen compartments configurations
Cliff morphology

yellow line: localization of cliff profile (right)

marls erosion
Failure mechanisms

- **Slide**: $w$ intersects a jointed face. Shear strength of discontinuities is mobilized.
- **Topple (or free fall)**: $w$ intersects a free face. Tensile strength of discontinuities is mobilized.

![Graph showing percentage distribution of failure mechanisms.](image)
Conclusion

Based on laser scanner data, the structural analysis permitted to know the joint sets cutting the rocks, and their link with the global cliff morphology and the failure configurations.

The main failure configurations and mechanisms have been identified and could be used for localized hazard detection.

The next step of this work is to associate the rockfalls detected with meteorological conditions thanks to a continuous photographic survey (each 10min, since January 2013), which will provide the date and hour of each event.