Structural Constraints on Deep-seated Slope Deformation Kinematics

F. Agliardia, G. Crostaa, A. Zanchib
Engineering Geology 59 (2001) 83-102

Presenter: Wan-Qian Luo

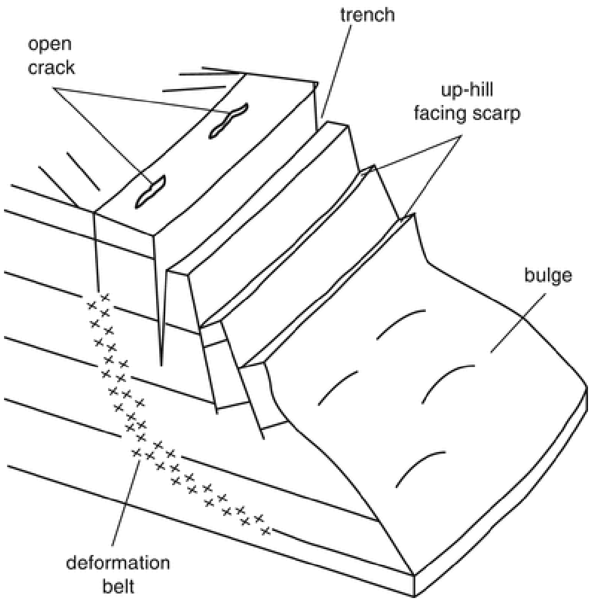
Advisor: Prof. Wen-Jeng Huang

Date: 2024/12/06

Introduction

- **What is "deep-seated gravitational slope deformation (DSGSD)" ?**

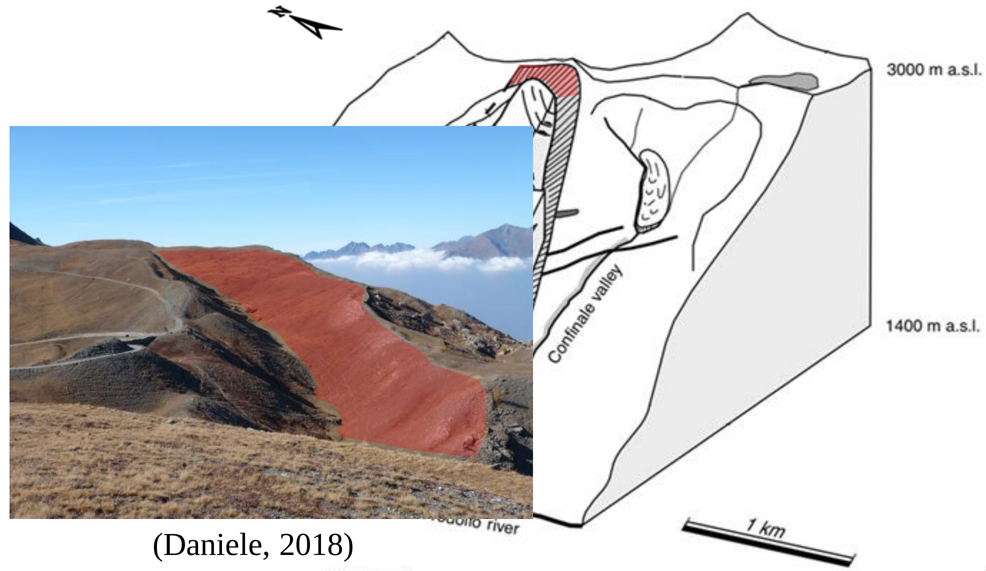
Refers to specific characteristics of rock-mass movements that affect high-relief mountain slopes, moving and deforming in extensional, shearing, or mixed mode at low rates (mm/year) over long periods.



(Soldati, 2016)

- **What is "Sackung-type" ?**

A deep fracture caused by gravitational sliding, often found near the tops of mountain ranges.

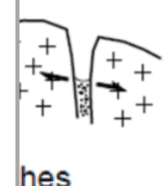


(Daniele, 2018)

3D model of study area

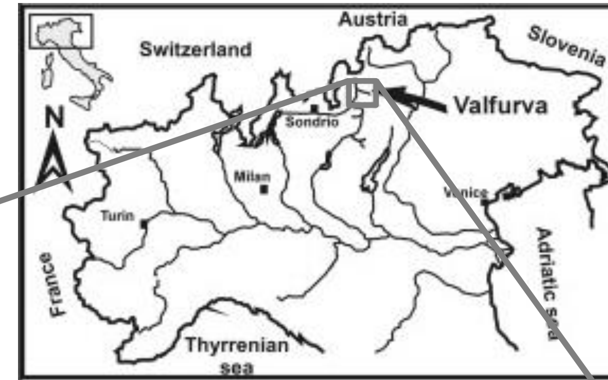
Morpho-structural features typical of DSGSD

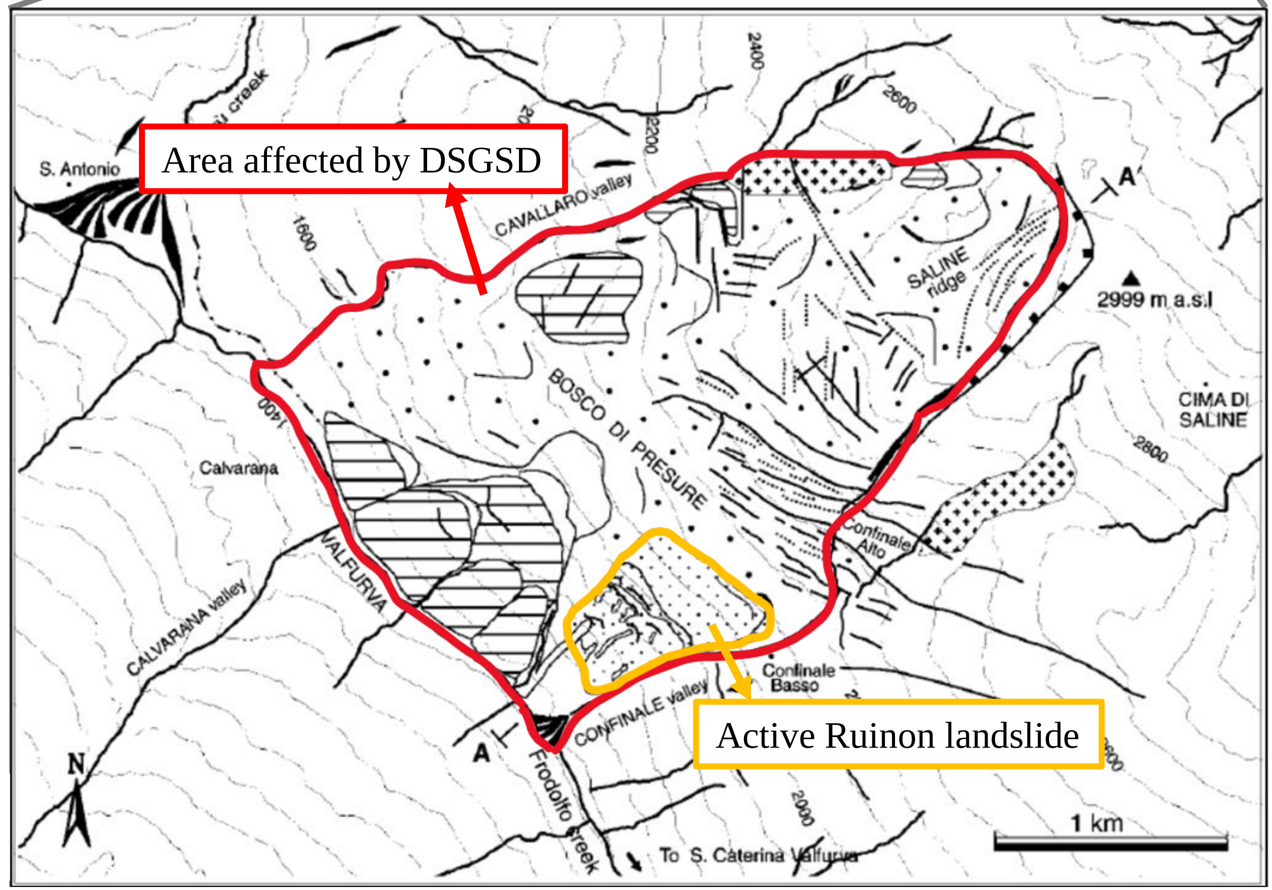
"Morpho-structure" is describe the morphological expression of a deformational structure of tectonic or gravitative origin, or resulting from their interaction.

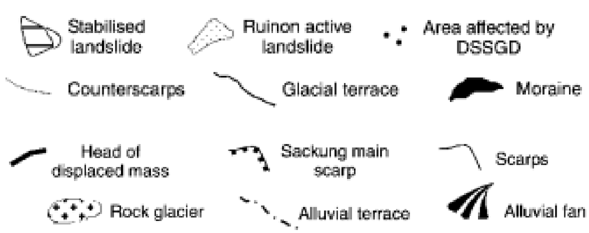


Introduction

- **Sackung-type DSGSD** was recognized in the northern part of Italy.
- The main lithology of the study area consists of phyllites (**metamorphic rock**).
- Superficial deposits cover most of the area and consist mainly of glacial deposits or rock glacier deposits.







Geomorphological and morpho-structural map of the study area

Introduction

Dangerous!!

Deep-seated deformation can create a sliding surface within the slope, further destabilizing the mountain.

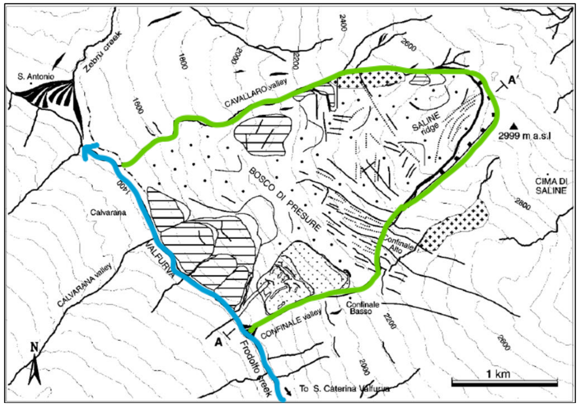
Knowledge of the kinematics of deep-seated deformation can be useful to understanding the evolution of landslides and predicting their development.

Objective

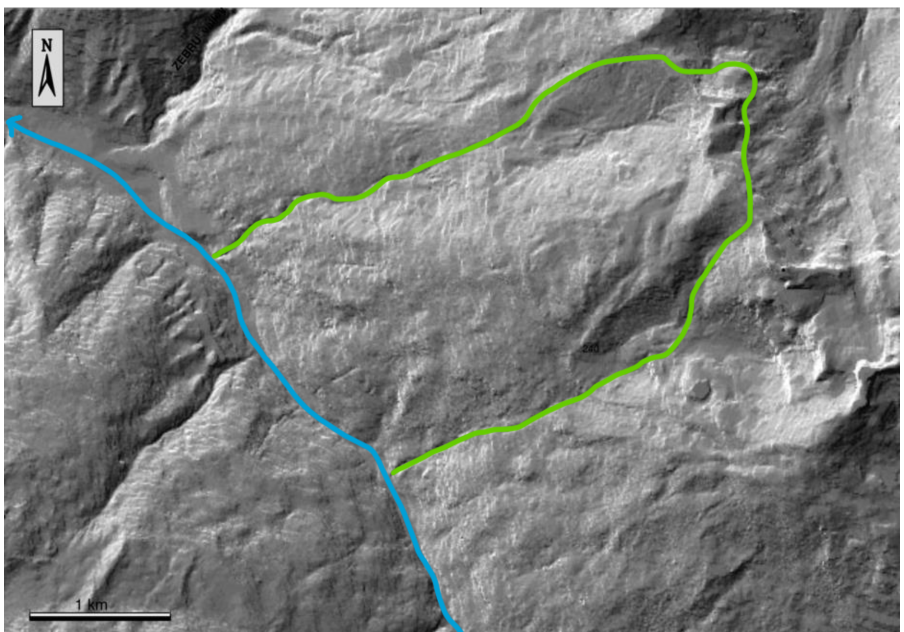
1. Analysis the kinematics of DSGSD in study area.
2. Causes and triggering factors of DSGSD phenomenon.

Methods and Results

1. Shaded relief map



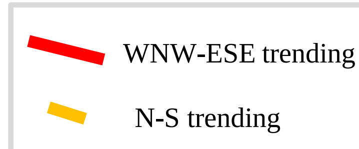
Geomorphological and morpho-structural map of the study area

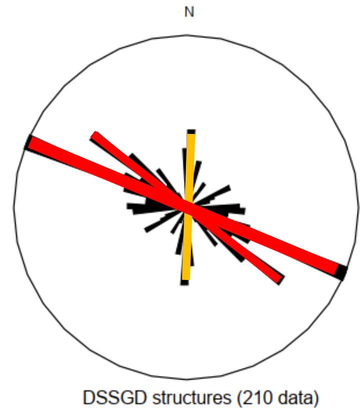


Shaded relief map (based on the digital elevation model (DEM)) of the study area

2. Geological field surveys

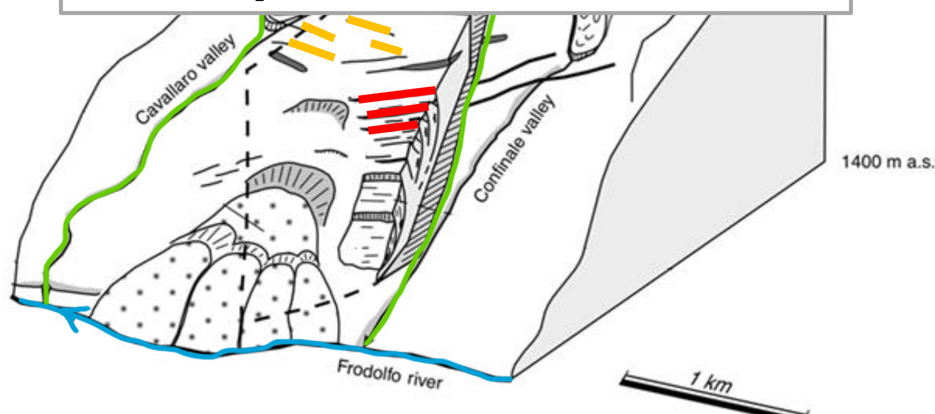
WNW-ESE and N-S trending fracture systems being the most common in the study area.





Rose diagrams (5° intervals)

These fractures make the rock mass weaker in specific directions, causing the slope to more easily undergo deep-seated deformation along these weak planes.



3D model of study area

Methods and Results

Two-dimensional geomechanical simulation code.

3. Numerical modelling (Use FLAC 2D)

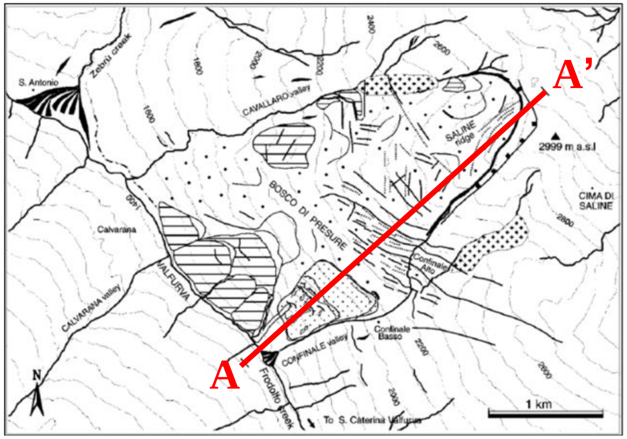
These simulations were performed to test the mechanical consistency of the kinematic hypotheses about the slope's evolution.

60 × 75 finite-difference grid

Boundary condition: constrained by displacement-type

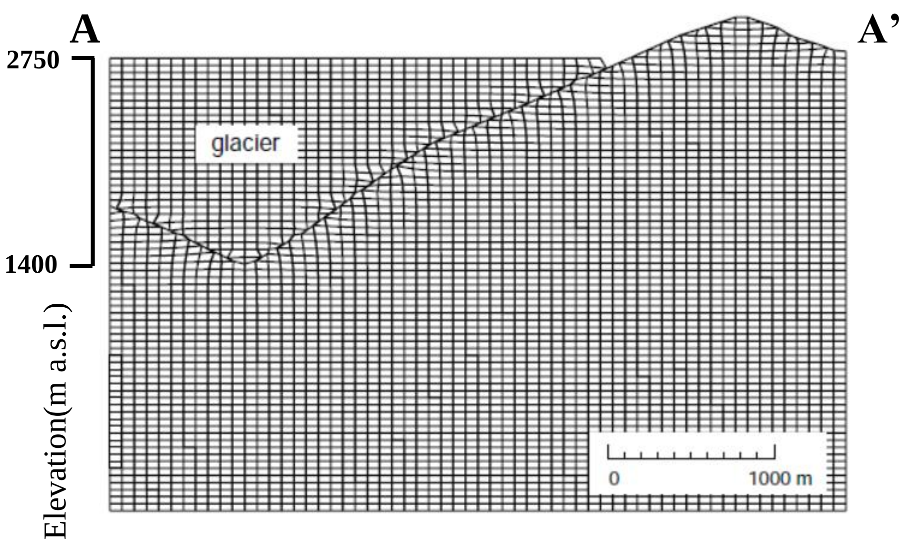
Material: Elasto-plastic

With a transversal anisotropy dipping at 75° downslope relative to the horizontal.

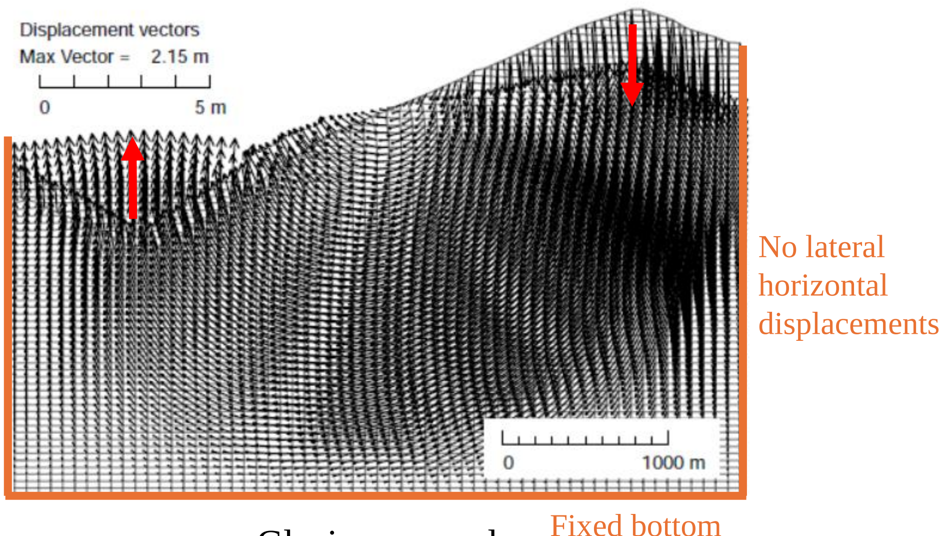


The NE directed cross-section A–A'

And then glacier removal was simulated by gradually taking away thin layers of ice one at a time.



Initial conditions



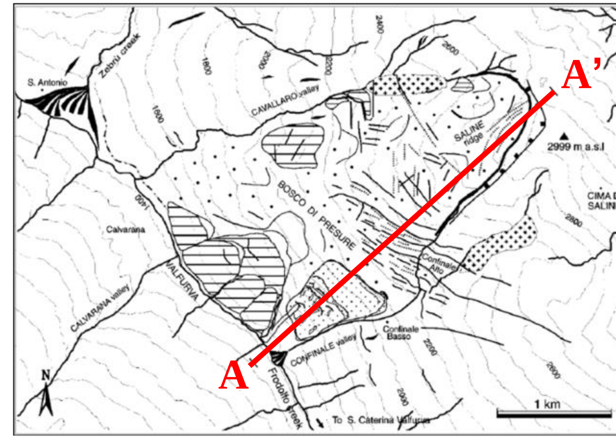
Glacier removal

Results

3. Numerical modelling (Use FLAC 2D)

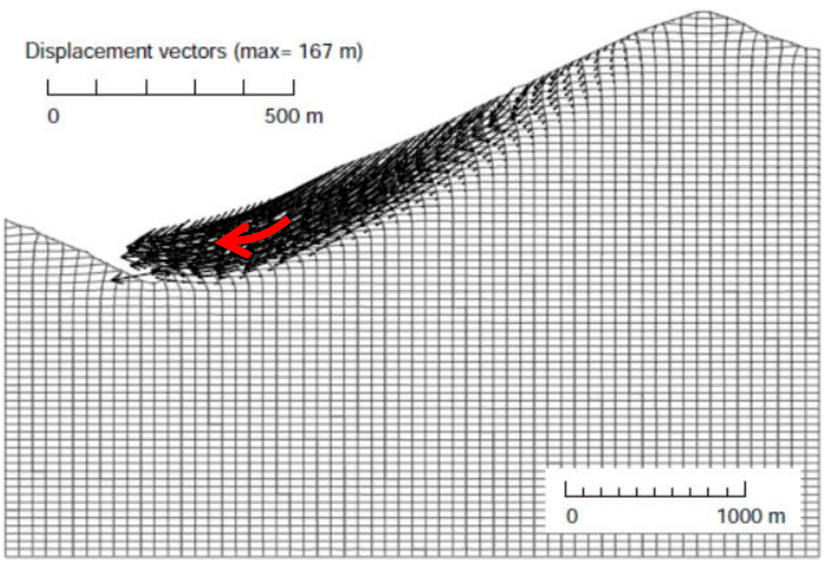
After the complete removal of the glacier, significant increase in deformation occurred.

Grid displacement monitoring showed a maximum displacement of up to 167 meters.



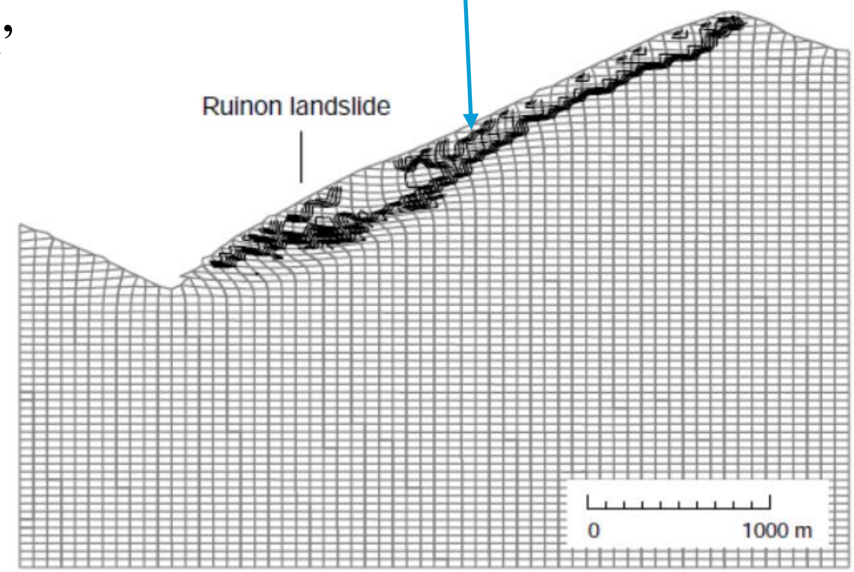
Lines are connecting areas that meet the yield criterion(屈服標準).

A



Total displacements

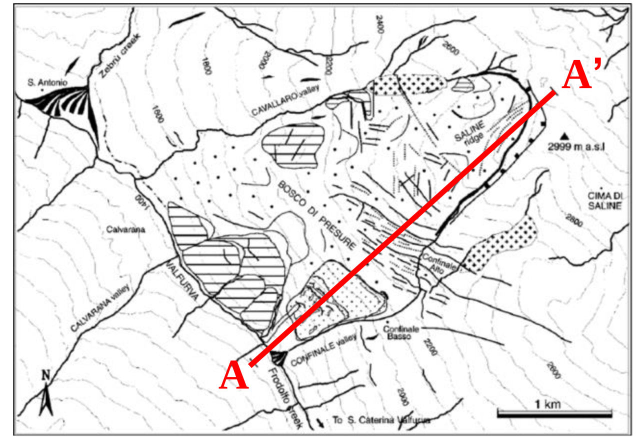
A'



Plastic state

Results

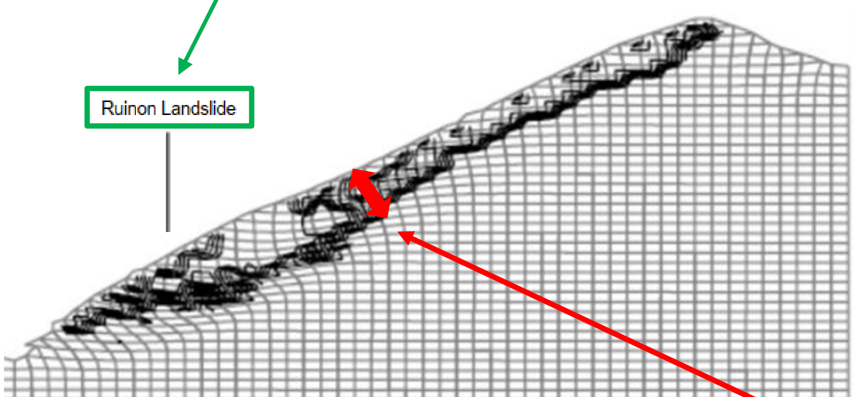
3. Numerical modelling (Use FLAC 2D)



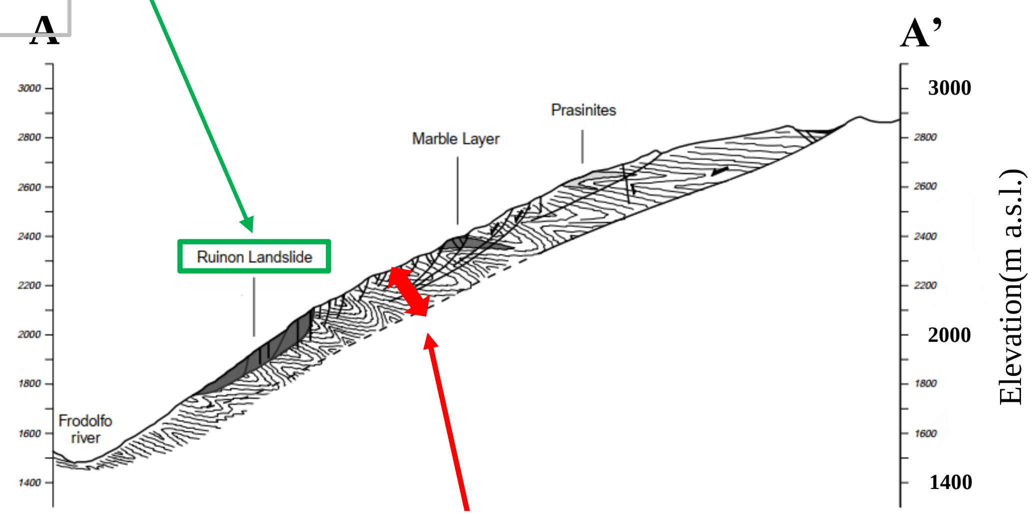
A superficial failure is evident at the toe bulging, corresponding to the large displacements as the active Ruinon landslide.

Test models run without the fracture did not show the same location observed in the field.

This suggests that structural control may be a necessary condition for the development of the phenomenon.



Plastic state



A-A' Geological and morpho-structural cross section

A 200-300 m deep basal slip surface.

Discussion and conclusions

1. DSGSD began to move after the glacial removal at the end of the glaciation, continued into recent times, and is possibly still active at low to very low rates of displacement.

2. The kinematics of the Ruinon landslide appear to be closely linked to those of the whole slope, as suggested by the continuous downslope increase of activity along the WNW-ESE trending morpho-structures located above the landslide crown.

3. According to the numerical simulation, the triggering cause of the phenomenon is related to the removal of the glacier, which caused significant unloading of the slope.

Thank you for listening