A multidisciplinary methodology for the characterization of a large rock spread in the Northern Calcareous Alps

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Introduction

Recent rockfall activity at Mt. Plassen (Fig.1) provide evidences for significant displacement rates of this large rock spread area. A multidisciplinary assessment strategy was chosen to analyse the ground conditions to characterize the potential failure mechanisms in more detail and to evaluate the hazard potential of future events.

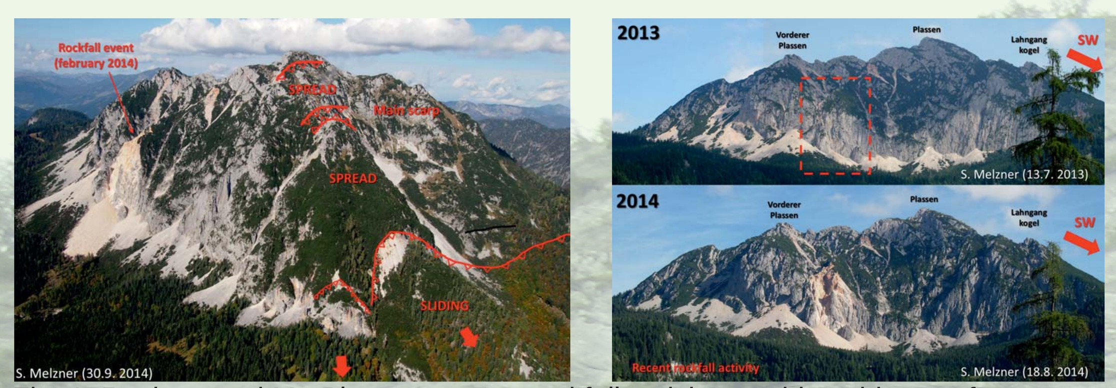
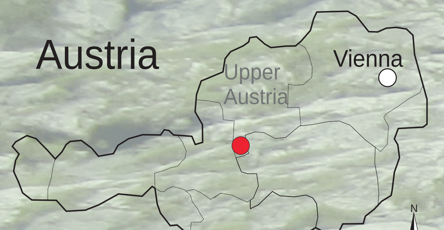


Fig. 1: Rock spread Mt. Plassen, recent rockfall activity provide evidences for significant displacement rates of the rock spread (photos by S. Melzner).

Survey area

Mt. Plassen is situated west of the Hallstatt village in Upper Austria. The area is part of the Hallstatt-Dachstein/Salzkammergut World Heritage Site.



Tectonic and geologic settings

The study area is part of the Northern Calcareous Alps and is characterized by complex lithological and tectonic settings see Fig. 2 & 3).

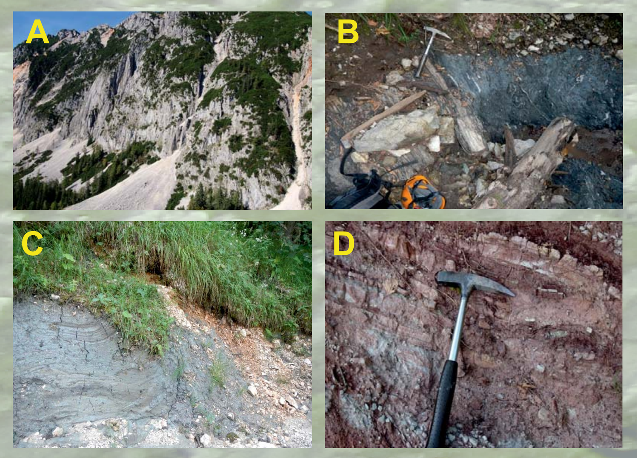


Fig. 2: Geological units differ significantly in their geomechanical properties. The Jurrassic limestone (A) overlie Permo-triassic, fine-grained, clastic rocks and evaporites (B-D) (photos by S. Melzner).

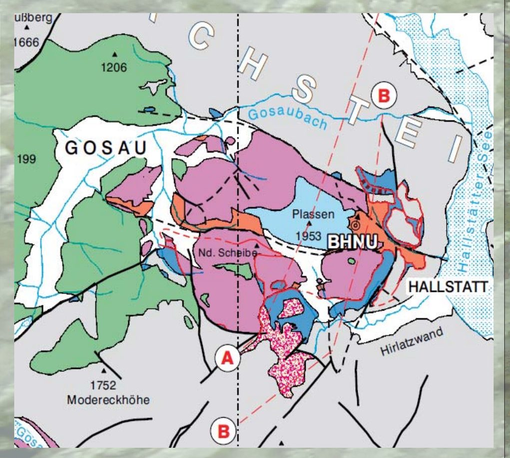


Fig. 3: Geological map of the study area. grey= Dachstein limestone, light blue= Plassen limestone, lila= Hallstätter limestone, orange= Werfen beds and Haselgebirge, dark blue= Allgäu formation (Mandl et al. 2012).

The Salzberg Hochtal is characterized as a „hard-soft-situation" comprising Triassic (Hallstätter Facies) and Jurassic limestone (Plassen Schollen of the Hallstätter Zones) (Mandl et al. 2012). These rocks overlie Permo-triassic, fine-grained, clastic rocks and evaporites, mainly the so-called Haselgebirge (Fig. 3).

This geotechnical predisposition causes rock spreading of the more hard and rigid limstone (Fig. 3A) on the weak, mainly clayey rocks (Fig. 2 B-D).

Associated to this large slope instability are secondary rockfall and sliding/toppling processes (Fig. 1). Further common process chains include rockfall triggering slides and/or earth flows by undrained loading of the weak clay material.

Results

Geological predisposition

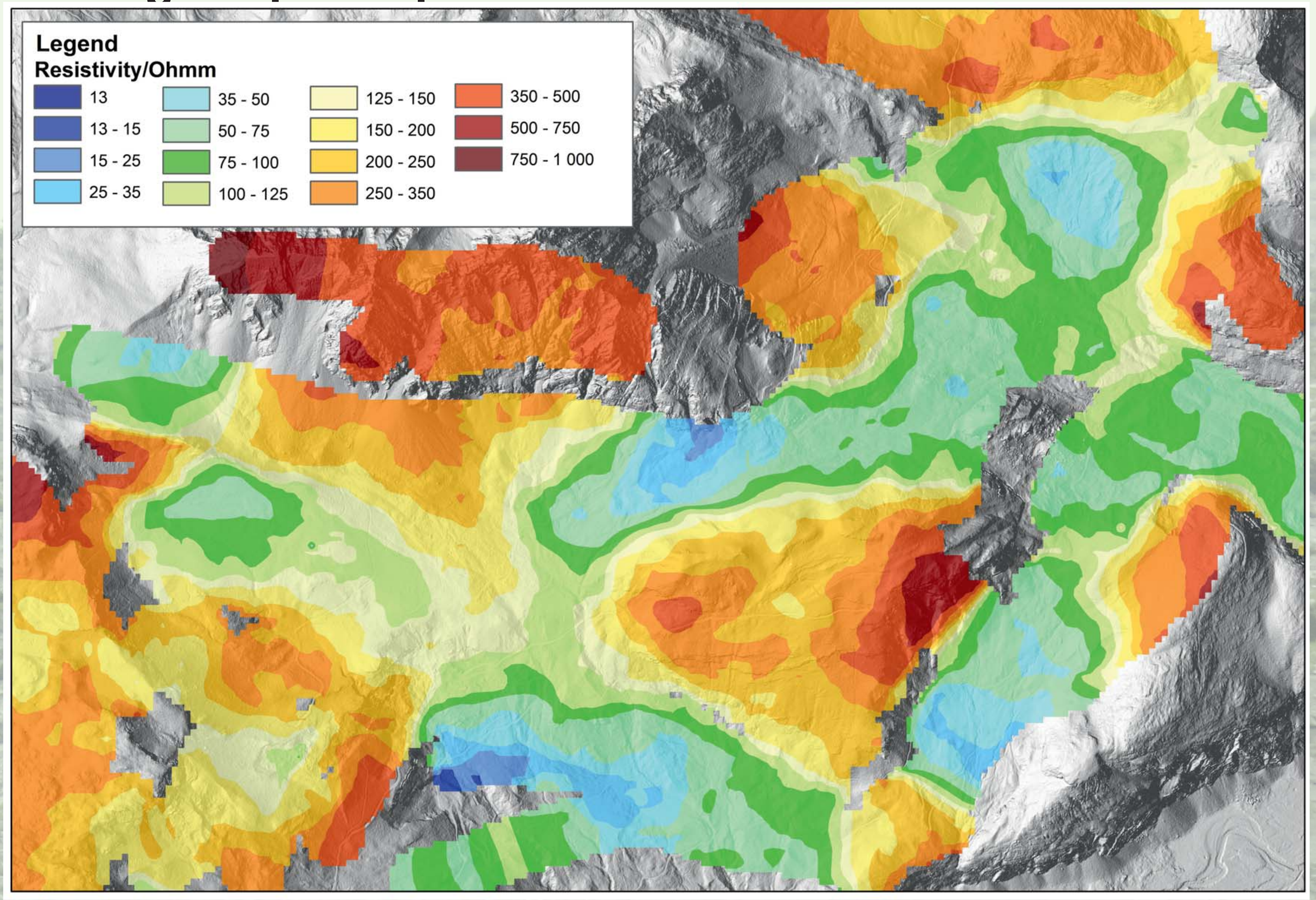


Fig. 4: The pattern of the resistivities shows a good correlation between the different lithological units, which provides lateral delineation and depth up to 70m of these units.

Failure mechanisms

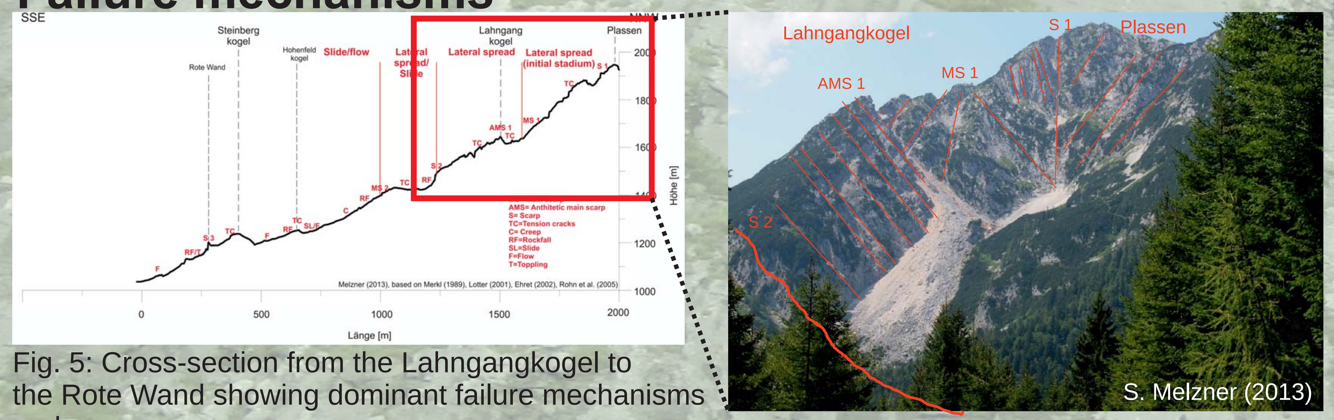


Fig. 5: Cross-section from the Lahngangkogel to the Rote Wand showing dominant failure mechanisms and processes.

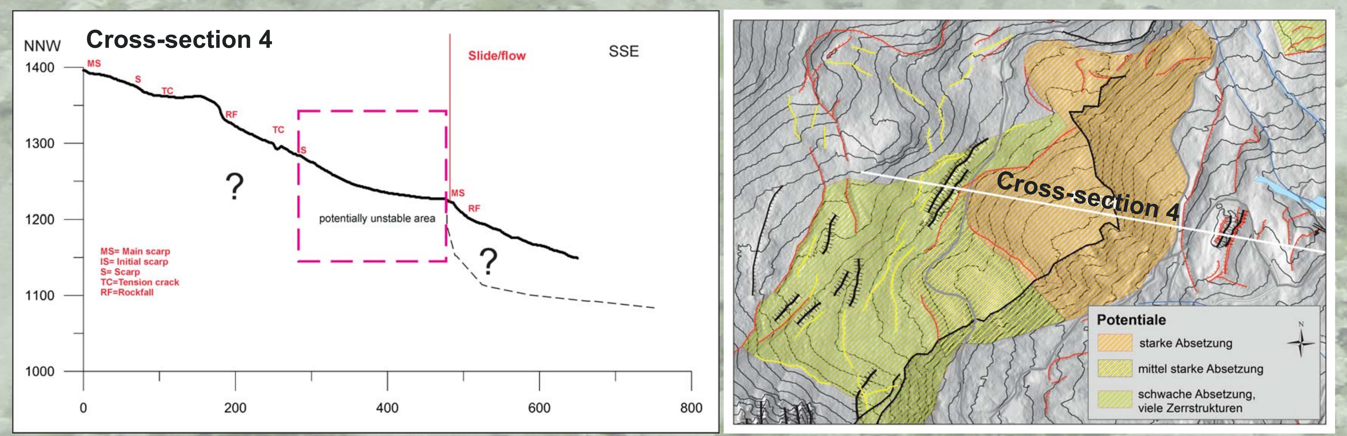


Fig. 6: Mapping of potential unstable areas and selection of cross-section for geoelectric measurements.

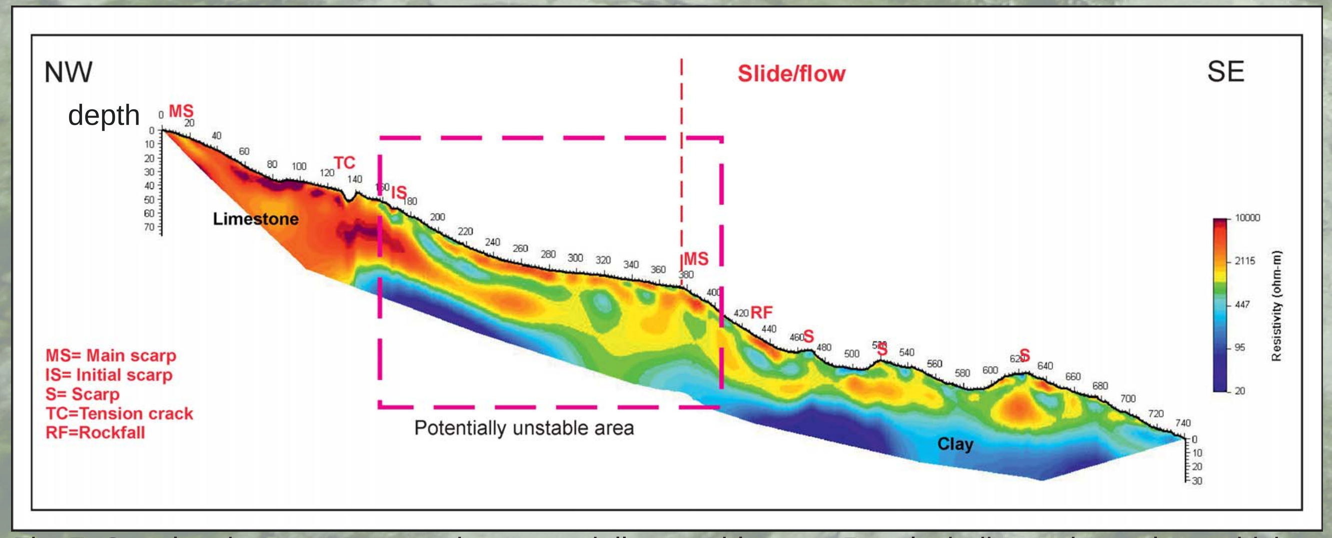


Fig. 7: Geoelectric measurements in a potentially unstable area. Results indicate shear plane which may result in a sliding failure. Orange= limestone; (dark) blue= clay, marl; for location see white line in Figure 6.

Active process areas

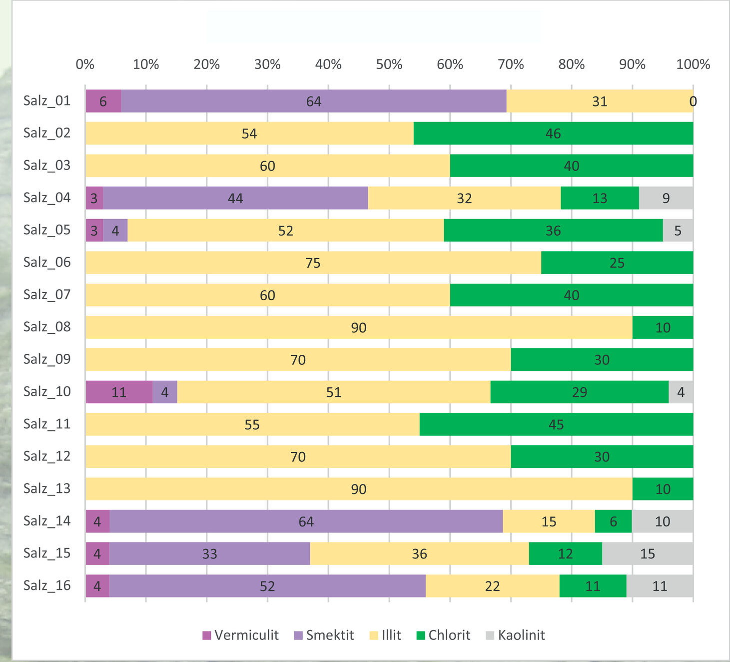


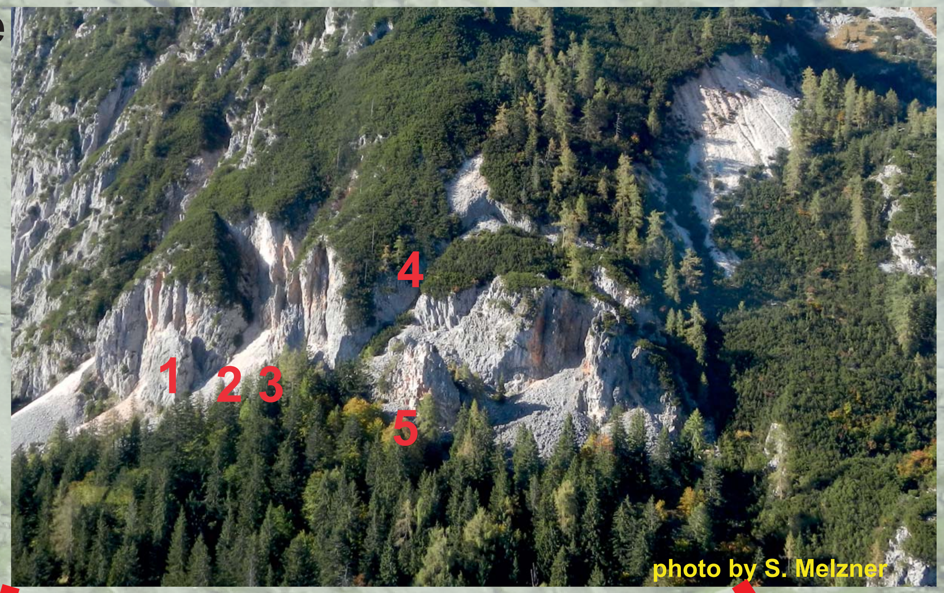
Fig. 8: Clay mineral composition of the fraction<2um.
Representative samples were taken from 16 locations within scarp or accumulation of active slides, earthflows or creeps.
To the main part the material consists of silty clays of Upper Permian Haselgebirge, mixed with silty Werfen Beds of Lower Triassic and sandy silts and marls of Zlambach Beds (Uppermost Triassic) and Allgäu Formation (Lower and Middle Jurassic).
Allgäu-und Zlambachschichten: very high contents of smectite and illite besides small amounts of chlorite and kaolinite
Haselgebirge: predominant illite/muscovite and chlorite
Werfener Schichten: highly variable grainsize distribution; clay mineral assemblages of illite/muscovite and chlorite similar to Haselgebirge

Relative divergence of rock towers

Fig. 9: Kinematic measurements at the Dammwiese:

Relative divergence at the measuring section 2 and 3 nearly linear of about 12mm/year
-> creeping of rock towers/slaps overlying the weak Haselgebirge

Joint mass structure of the rock tower „2a" in comparison to the scarp area
-> toppling



Displacement rates Mt. Plassen

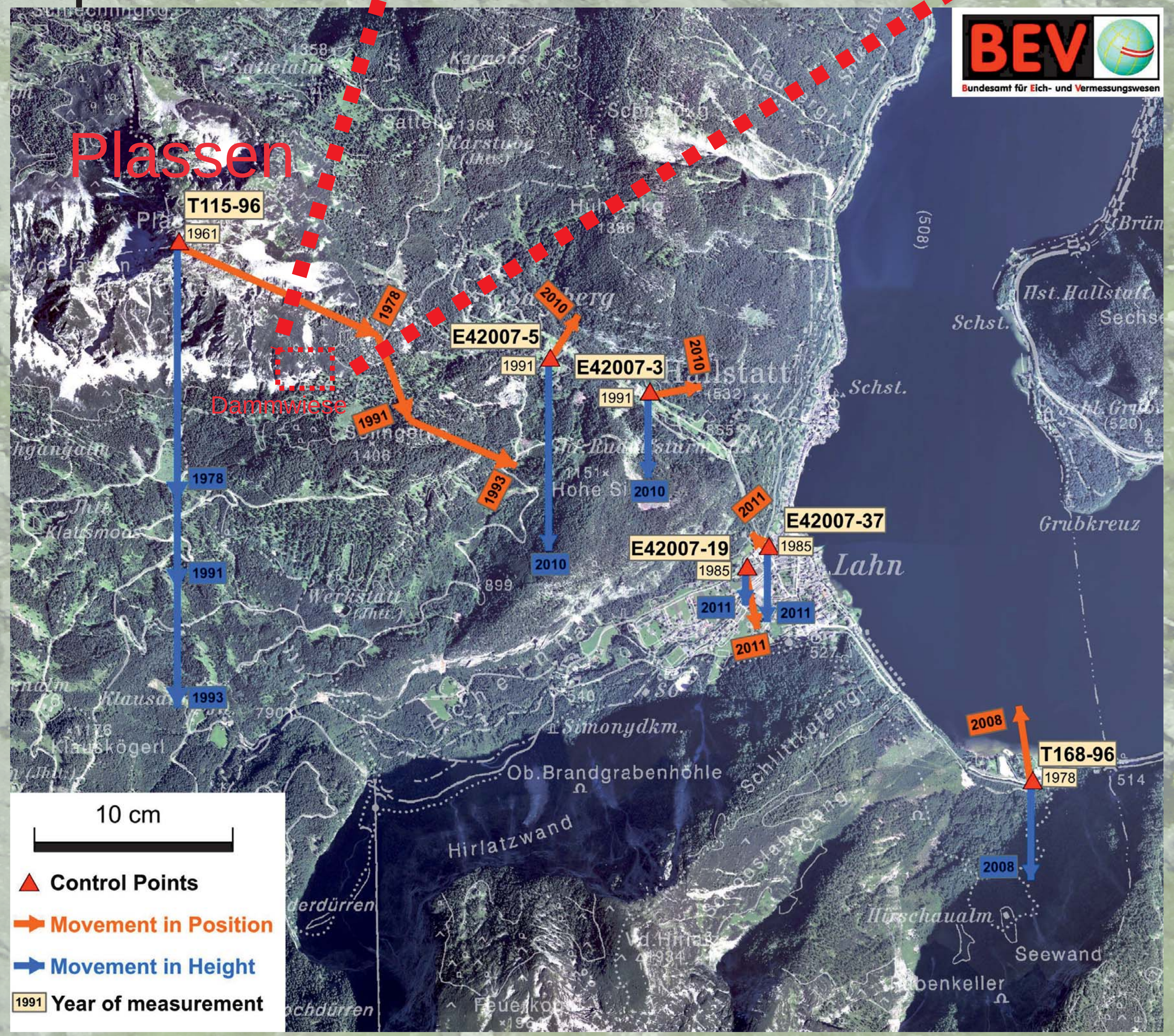


Fig. 10: The point T115-96, near the peak of Mt. Plassen, was measured four times from 1961 to 1993. The analysis of the data shows significant movements of the control points (Source: Department „Control Survey" of BEV).

Methodology

A multidisciplinary assessment strategy was chosen to analyse the ground conditions, to characterize the potential failure mechanisms in more detail and to evaluate the hazard potential of future events. Methods include

* field mapping (geology, engineering geology and geomorphology)
* sampling and determination of soil parameters in active process areas
* geophysical survey (airborne geophysics and geoelectric measurements)
* kinematic measurements: tape dilatometer and geodetic measurements

Conclusions

The multidisciplinary assessment strategy proofed to be suitable to analyse predispositional factors and failure mechanism within the study area:

* several unstable areas exist along the Plassen massif which either will fail in a sliding or in a falling/toppling mode
* kinematic measurements show significant movement rates of the large rock spread
* relative divergence of rock towers from the Plassen massif with more than 1 cm per year as a long term continous movement rate
* absolute displacement rates Mt. Plassen:
  1961-1978: 0,7m horizontal to SE, vertical 0,13m
  1978-1991: 0,05m horizontal to S, vertical 0,1m
  1991-1993: 0,055m horizontal to SE, vertical 0,06m
* the clastics beds have a medium to high plasticity due to the high clay content, which results in a high susceptibility towards the occurence of creeping and sliding processes and as well as undrained loading
* geophysical methods allow the detection of the basal plane of the hard limestone above the weak sequences

Fig. 11: Hazard potential for future sliding (left) and rockfall (right) along the Plassen Massif (photos by S. Melzner).

Acknowledgments

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